POWER

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The Beginning

I SUPPOSE that everybody, whether he has made much or little of his life, can look back to some moment that has decided his course from then on.

The parallel has often been drawn of a drop of rain falling upon the crest of the Rockies. A breath of wind, the position of a stick or the slope of a stone may determine whether it flows ultimately into the eastern or the western ocean.

A few days ago a letter came in from an engineer in the West who has made good. He has responsibility, respect and revenue. And he says that as he reviews his life, his mind goes back to a day when he was working in a steam plant for small wages, and a canvasser for a correspondence school and one for *Power* called upon him at the same time.

Their appeals supplemented each other, led him to think of what was going on in the world of engineering, and aroused the conviction that he could have a part in it.

The spark was lighted. He read and studied and thought. He applied what he learned, and when he outgrew the opportunities of his position, he hustled for another where the kind of applied knowledge, the combination of learning and practice that he was getting, was wanted.

And as he worked and thought, he saw better ways of doing things and tried them. And one of his inventions worked so well that others wanted it, and it turned out to be the foundation of the successful business of which he is the president.

And he dates his start from that day when the study habit first got hold of him, and he began to use his brain as well as his hands.

Huge Savings Possible by the Use of Byproduct Power

By LEWIS J. SFORZINI

IN ALMOST all industries involving chemical or physical processes using heat, steam is demanded at pressures ranging from a few inches of vacuum in some plants to 250 lb. or more in others. Furthermore, almost without exception these same industrial plants have demands for mechanical or electrical power. The ratio of the steam load to the power load or, in other words, the ratio of the number of pounds of process steam required to the number of horsepower-hours of electricity used, is dependent on the nature of the industry. Owing to this diversity of requirements, there have arisen all sorts of combinations for obtaining both the steam and the electricity.

The simplest method of obtaining a desired process-steam pressure, and one that is applicable to any pressure, is to operate the boilers at the desired steam pressure plus line drop, and to run the steam directly from the boiler to the process. This requires no equipment except that contained in the boiler room; but of course no power can be obtained from a plant of this nature. Again, there are localities where power can be purchased so cheaply that it is economical to supply process steam direct from the boilers and buy all the power needed. Sometimes the demands for power are so low or the desired process pressure so high that this is the only practicable arrangement.

WOULD you consider buying a prime mover with a guaranteed steam consumption of less than three pounds per horsepower per hour? The opportunity is there if your plant supplies any large amount of process steam direct from the boilers or through reducing valves. The facts about byproduct power are relatively simple and easily understood, yet the money wasted every year in the United States by lack of knowledge of this subject amounts to millions of dollars. If you have anything to do with the production or use of process steam, read this article. It may save your company a lot of money.

When only one boiler pressure is carried in a plant and there are two or more processes, each demanding separate temperatures, recourse may be had to (1) reducing valves, or (2) a steam engine or turbine. For a reducing valve, connections would be made as shown in Fig. 1. Here saturated steam is taken from the boiler at a pressure around 100 lb., and sent through a reducing valve, which by throttling reduces the pressure to, say, 5 lb. The globe valve shown is used for throttling by hand when the reducing valve is out of order.

If we assume the steam to be initially dry and saturated, the pressure and temperature of the steam entering the reducing valve would read as is shown on the right, and the heat content would be 1,189 B.t.u. per pound. After the steam passes through the reducing valve, the pressure gage and the thermometer would read as shown on the left. The temperature of 297 deg. and superheat of 70 deg. may be found in the superheated-steam tables opposite 20-lb. absolute (5-lb. gage) and under 1,189-B.t.u. total heat. Except for the negligible radiation loss, pressure reduction by throttling involves no heat loss, the low-pressure superheated steam containing 1,189 B.t.u., the same as the original high-pressure saturated steam. This means that from the thermal (heat) standpoint the reducing valve is practically 100 per cent efficient. From the thermodynamic (heat-power) standpoint throttling reduces the availability of the heat for producing power. In most processes the superheat formed would be of no advantage from a temperature point of view, since it would disappear at the instant of entering the process, were it not lost by line radiation before reaching the process.

Fig. 2 shows a steam engine used in place of the reducing valve for the same initial and final pressures. Here the temperature of 227 deg. on the low-pressure side corresponds to the saturation temperature, because the exhaust steam is wet owing to the heat taken out as power by the engine. A calorimetric test of the steam would show it to be only 96 per cent dry if the water rate were 45 lb. of steam per horsepower-hour and the heat loss from the engine 25 per cent of the power output. This dryness corresponds to a heat content of about 1,118 B.t.u. per pound. The essential difference between a steam prime mover and a reducing valve is that the reducing valve removes no heat, while the prime mover takes out the small amount represented by the power produced and the radiation losses from the prime mover. These radiation losses include the friction losses in bearings and other places not in contact with the steam. The heat produced by internal friction stays in the exhaust steam.

One horsepower-hour is equal to 2,545 B.t.u. If the radiation losses are assumed to be 25 per cent of the energy turned into power, the total heat taken out of the steam for every horsepower-hour will be

$$2{,}545 + 25 \textit{ per cent} \text{ of } 2{,}545 = 2{,}545 + 636 = 3{,}181 \textit{ B.t.u.}$$

Since the heat required to produce a pound of steam averages about one-third this amount and does not vary much within the practical range of pressures and superheats, the steam *chargeable* to power is only about three pounds per horsepower-hour, where the exhaust is completely used for process heating. That is to say, the total weight of steam required from the boiler would be that required if a reducing valve were used plus only about three pounds per hour for every horsepower taken out by an engine or turbine used in place of a reducing valve. This is true regardless of the efficiency or water rate of the prime mover.

The water rate does, however, affect the heat and dryness of the exhaust steam, because the less steam used per horsepower-hour the greater is the amount of heat taken out of *each* pound. In the case just cited, the engine transmits 45 lb. of steam per hour for every

horsepower, so the amount of heat taken out of each pound is 3,181 ÷ 45 = 71 B.t.u., leaving a final heat content of 1,189 — 71 = 1,118 B.t.u. From the steam tables it is found that steam at 5-lb. gage contains this amount of heat when it is 96 per cent dry. A lower water rate would give wetter exhaust steam.

To figure the coal consumption chargeable to byproduct power, we may go back to the round number of 3 lb.

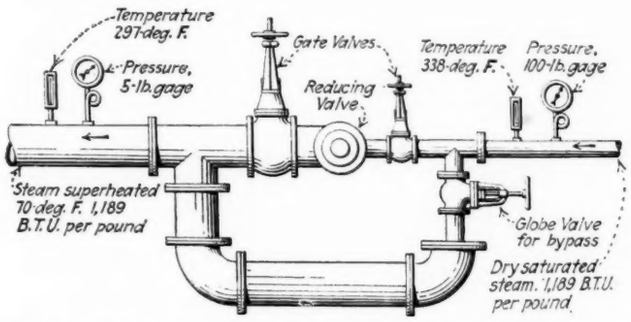

Temperature 297-deg. F.
Pressure, 5-lb. gage
Gate Valves
Reducing Valve
Temperature 338-deg. F.
Pressure, 100-lb. gage
Steam superheated 70 deg. F. 1,189 B.T.U. per pound
Globe Valve for bypass
Dry saturated steam. 1,189 B.T.U. per pound

FIG. 1—WHAT HAPPENS WHEN STEAM PASSES THROUGH A REDUCING VALVE

There is no loss of heat in passing through the valve. If the steam is dry saturated at the start, it must be superheated at the finish to have the same amount of heat.

steam per horsepower-hour. Allowing an average evaporation of 7½ lb. per pound of coal, this gives a coal consumption of 3 ÷ 7.5 = 0.4 lb. coal per horsepower-hour. These figures (3 lb. steam and 0.4 lb. coal) are worth remembering, noting that they apply in cases where all the exhaust is utilized.

With coal at $8 a ton (0.4c. a pound), the fuel cost for one horsepower of byproduct power would be 0.4 × 0.4 = 0.16c. per hour. To get the total cost it is necessary to consider what additional investment and operating expenses are incurred *in addition to* those that would be necessary if no power were developed from the process steam. The chief additional cost is for the installation and care of the engine or turbine. The additional requirements in boiler capacity are insignificant. If these items amounted to 0.4c. per horsepower-hour, the total cost would be 0.16 + 0.4 = 0.56c. per horsepower-hour.

These figures show clearly why the steam engine or turbine is used so extensively for reducing pressures to points below 20-lb. gage when the process-steam demand is spread over a reasonable number of hours.

In those industries where the electric load is small compared to the process-steam load and yet is sufficiently large to make possible the installation of a non-condensing steam unit, the excess-steam requirement is made up with reducing valves from the boiler pressure. In such a case the reducing valves might represent good practice. Still, were the possible surplus electrical output large enough, a profitable arrangement might be made with the local public utility for the absorption of this surplus.

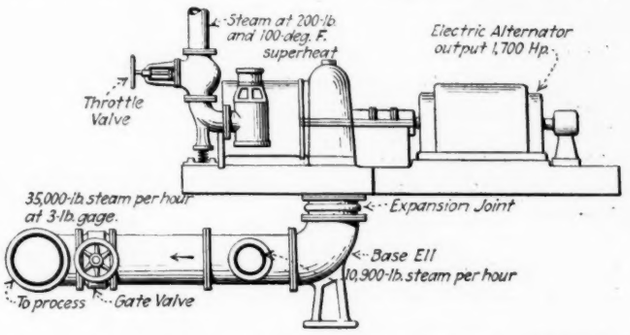


FIG. 3—EXHAUST IN EXCESS OF PROCESS DEMANDS ESCAPES TO ATMOSPHERE

Under the full-load conditions shown only 6.4 lb. of steam per horsepower-hour is chargeable to power, although about 10,900 lb. per hour is escaping to the atmosphere.

Certain industries have an electrical load far exceeding the output obtainable as a byproduct from the process-steam load. In such cases there are many ways of combining the steam and electric loads. A common method is to meet the surplus requirements by purchased power, but this is not always advantageous, especially if the extra demand is large.

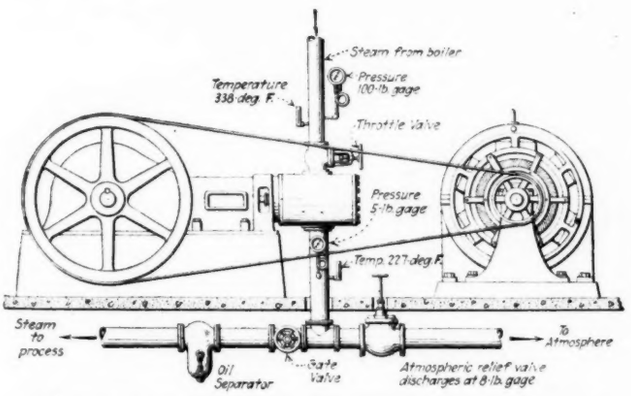


FIG. 2—STEAM ENGINE SUBSTITUTED FOR REDUCING VALVE OF FIG. 1

The engine reduces the heat in the steam somewhat, the total reduction being equivalent to a steam consumption of 3 lb. per horsepower-hour. This figure is practically independent of the type of engine or its actual water rate.

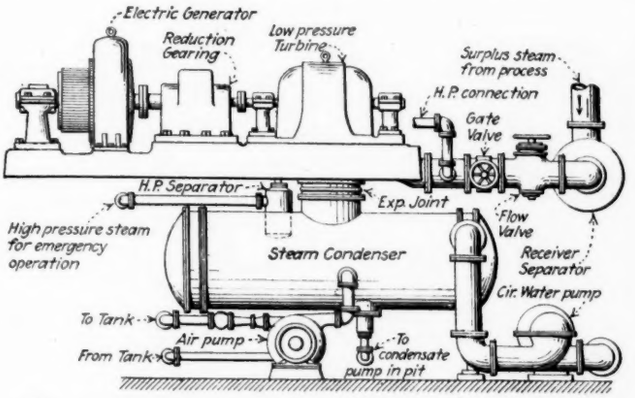


FIG. 4—APPLICATION OF LOW-PRESSURE CONDENSING TURBINE

Where the electrical load exceeds the steam load, it is often economical to exhaust all high-pressure engines and turbines to a common exhaust main, allowing any excess not used by the process to develop power in a low-pressure turbine.

Another method in extensive use, particularly when the electric load exceeds the process load only at peak periods, is to run the engine or turbine at the pressure demanded by the process and to allow any surplus of steam to escape to the atmosphere. In certain cases this is cheaper than to purchase power.

As a concrete example take a turbo-alternator, as shown in Fig. 3, with 200-lb. pressure and 100-deg. superheat at the throttle, a back pressure of 3-lb. gage,

a water rate of 27 lb. of steam per horsepower-hour at the rated load of 1,700 hp., and a process load equivalent to 35,000 lb. per hour of the high-pressure superheated steam.

To run the turbine at rated load will require 1,700 × 27 = 45,900 lb. of steam per hour. As only 35,000 lb. of high-pressure steam per hour would be required if the turbine were not present, the difference, 45,900 — 35,000 = 10,900 lb., is chargeable to power. The equivalent water rate is 10,900 lb. ÷ 1,700 hp. = 6.4 lb. per horsepower-hour. Something less than the indicated 10,900 lb. of exhaust steam would actually be blown to waste because the process would require a little more than 35,000 lb. of the exhaust steam (owing to the fact that the exhaust steam contains slightly less heat per pound that the discharge from a reducing valve). It is, however, unnecessary to figure the heat in the exhaust steam in this particular case. There is, obviously, more than enough steam for the process, so the turbines can be charged only with the additional steam the boilers must generate. Assuming a steam cost, for the fuel alone, of 0.06 cents per pound, the fuel cost per horsepower would be 0.06 × 6.4 = 0.38 cents.

Low Power Cost in Spite of Wasted Steam

Since the excess steam used by the turbine or engine would require additional boiler capacity, we might expect a greater *additional* investment charge per horsepower than in the previous problem. This, however, would be largely offset by the smaller cost of the turbine per horsepower due to its larger size.

Taking the *net* additional cost at 0.4c., as before, the power cost in this case is only 0.38 + 0.4 = 0.78c. per

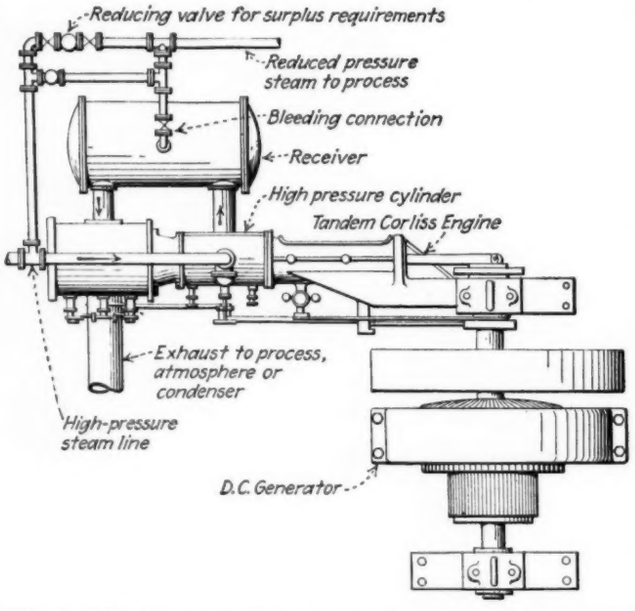


FIG. 5—COMPOUND ENGINE WITH PROCESS STEAM BLED FROM RECEIVER

When the reducing valve is closed and the low-pressure exhaust is all used for process work, the equivalent steam consumption is 3 lb. per horsepower-hour, the same as for a simple engine exhausting to a process.

horsepower-hour, although nearly 10,900 lb. of steam per hour is blowing to the atmosphere.

This case differs sharply from that where the process-steam requirement exceeded that of the engine. In that case the water rate of the engine had little effect on the power cost. In this case a better water rate would reduce the power cost by cutting down the total amount of steam the boilers must furnish.

Another method frequently used in large plants where the electrical demand exceeds the steam demand, and one that allows flexibility for variation of both the steam and electric load, is to extract the process steam at the desired pressure from a bleeder turbine, and to condense the remainder of the steam in a condenser. In this type of machine it is possible to obtain a fixed quantity of

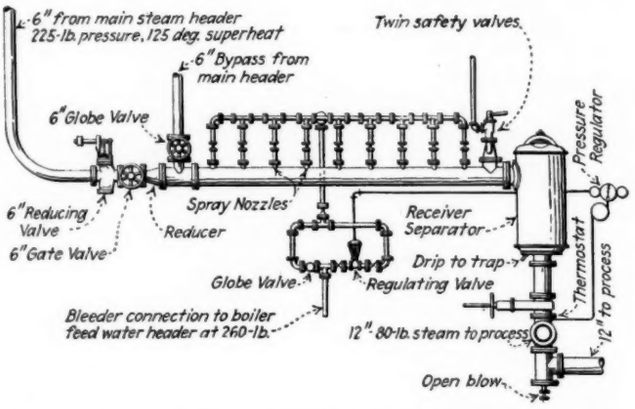


FIG. 6—A WASTEFUL METHOD OF FURNISHING PROCESS STEAM AT 80 POUNDS

process steam and a variable output of electrical power by condensing surplus steam, or the machine could be designed for a fixed electrical output with a variable process-steam load. Or again, the machine could be designed, with slightly less efficiency, for a variation of both. The bleeder turbine, for certain ratios of process load to electrical load, makes a highly efficient arrangement, and may have a water rate chargeable to power —for sizes even as small as 500 hp.—less than that of the most efficient large condensing unit now in operation.

Possibilities of Low-Pressure Turbine

Some industrial plants employ a low-pressure turbine, as shown in Fig. 4. A group of engines and turbines, all connected to a common exhaust main, are carried at the desired back pressure, any surplus process steam caused by excess power demands, being absorbed by the low-pressure turbine and condensed in the condenser. The receiver separator shown is to remove any moisture from the steam before it enters the turbine and to minimize the fluctuation in steam flow caused by the action of reciprocating units. This also is an efficient arrangement and is in effect the same as a bleeder turbine, having approximately the same water rate and cost for the same conditions. It possesses the advantage over the bleeder turbine that it can be shut down if there is no excess of process steam, or can be run by high-pressure steam at the boiler pressure through a special set of nozzles if the electric load continues when the process-steam load drops. This machine will also handle the exhaust from mill engines, pumps, air compressors, ice machines and other steam-driven electrical apparatus.

So far, because of a difference in the problem, nothing has been said about using the steam engine or turbine for reducing pressures to 20 lb. or over. Any large demand for steam at pressures exceeding 20 lb. had, until recently, been confined to a few industries and plants. This, coupled with the fact that boiler pressures in industrial plants were, until a few years back,

kept comparatively low, retarded the adoption of the steam prime mover as a pressure reducer for high pressures. However, the increasing popularity of the automobile in transportation has caused an enormous demand for steam in the rubber industry where pressures up to 80 lb. are required in the vulcanizers. The rubber industry, except during slack periods, is a 24-hour industry; it has large demands for electricity for driving mixing mills, banbury mixers, calenders, air compressors, fabric-cutting machinery, conveying machinery, etc. This condition has resulted in a serious study of the problem, and rubber plants are beginning to use the

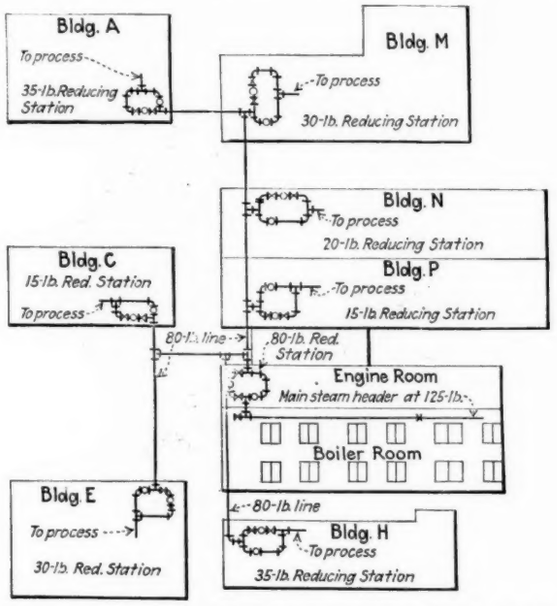


FIG. 7—CHANGES IN THIS LAYOUT WOULD SAVE $96,000 YEARLY

steam turbine as a pressure reducer, obtaining electricity as a byproduct.

Fig. 5 shows an arrangement that has been used for some time in certain textile and chemical plants for process pressures up to 45 lb. The high-pressure cylinder of the compound engine is made oversize and is proportioned to meet the average process-steam demand. The receiver also is extra large and the process steam is extracted from it, the remainder going to the low-pressure cylinder. Any peak demands with this arrangement are taken care of by the reducing valve, which becomes operative when the receiver pressure falls below a certain point. If the low-pressure cylinder discharges at a lower pressure to another process, the water rate chargeable to power is approximately 3 lb. per horsepower-hour as for the simple engine. If the low-pressure cylinder discharges to a condenser, the condition is similar to that with a bleeder turbine or that in a plant with a low-pressure turbine.

Huge Losses Still Continue in Process Plants

In spite of the enormous savings possible by the methods described, the majority of plants are still resorting either to low-pressure boilers with power obtained elsewhere, or else employing reducing valves to lower the pressure from a high pressure carried for other purposes. The use of reducing valves in certain plants has been carried to extremes. In one recent installation in a modern plant of a large industrial concern with a 24-hour steam and electric load, the writer observed the actual installation depicted in Fig. 6. Here steam is taken from the main header at 225-lb. gage and 125-deg. superheat, and is put through a reducing valve which throttles it down to 80 lb., in consequence of which the superheat is further increased, reaching 175 deg. All the superheat is then extracted by water bled from the boiler-feed header and injected into the 80-lb. header by spray nozzles, resulting in saturated steam at the same pressure. The surplus water is removed by the receiver separator shown. The diaphragm valve actuated by the thermostat controls the flow of the water. The amount of steam this plant uses at 80 lb. can be judged by the size of the two outlets under the steam separator. Taking the average steam flow as the capacity of only one 12-in. outlet at the unusually small velocity of 4,000 ft. per min., the process steam load would be about 40,500 lb. per hour, or 972,000 lb. per day for continuous operation.

Turbo-Generator Should Replace Reducing Valve

Imagine a turbo-generator substituted for the reducing valve. Assuming the steam at the turbine throttle to be at 200-lb. gage and 125-deg. superheat, the content of the steam at these initial conditions would be 1,272 B.t.u. per pound. For pure adiabatic expansion to 80-lb. pressure with no losses, the steam would then have a heat content of 1,200 B.t.u. per lb., a difference of 72 B.t.u. per lb. from the initial. If 44.5 per cent of this, or 32 B.t.u. per lb., were converted into power at the busbars, the electric power available would be:

$$\frac{32}{2545} \times 40{,}500 = 510 \text{ hp.}$$

This corresponds to an actual water rate of $\frac{40{,}500}{510}$ = 79 lb. of steam per horsepower-hour, but of course the water rate chargeable to power would be only about 3 lb. of steam per horsepower-hour, since all the exhaust is utilized. The steam in this example would still be superheated over 50 deg. after leaving the turbine, but the superheat would undoubtedly all disappear by radiation in the line to the processes, pumps, etc., which are some distance away.

This plant happens to buy a large part of its power, the rest being obtained from non-condensing units discharging to processes at a low pressure. If the cost of purchased power for 24-hour operation were 1c. per horsepower-hour, the cost for 510 hp.-hr. would be $5.10.

Plant Could Save $25,000 Yearly

If a turbine were used no extra engine-room help would be required and very little additional boiler capacity, so that practically the only charges would be those on the prime mover and electrical equipment.

Allowing a steam cost (including these additional charges) of $1 per 1,000 lb., this amount of power could be generated by the turbine for $510 \times 3 \times \$0.001 = \$1.53$, a saving of $3.57 per hour. As this plant operates twenty-four hours a day for 300 days a year, the yearly saving would be $\$3.57 \times 24 \times 300 = \$25{,}700$ (approximately).

It is to be noted that no question of economical pipe size enters into this proposition as the pipe sizes beyond the separator would remain the same as for the reducing valve.

In another power plant that came under the writer's observation, there existed a condition similar to that shown in Fig. 7. This concern used on an average

about 2,000,000 lb. per day of high-pressure process steam for about 340 days per year with a very even hourly distribution for the 24 hours. The boiler pressure was carried at 125 lb. The majority of the boilers had no superheaters, but boilers aggregating 30,000 sq.ft. were bought for 200-lb. operating pressures and were equipped with superheaters. All the boilers were connected to a common header where the saturated and superheated steam mixed somewhat, but provisions were also made for segregating the two kinds of steam. The process-steam pressure was reduced to 80 in the power plant and then sent through lines where in most cases the pressure was further reduced to 15 lb., 20 lb., 30 lb. and 35 lb., depending on temperature required for the particular process. Since the quantity of steam distributed was so large, the pipe sizes were not the limiting factor, as the volume of steam handled at 40 lb. would be only about 1.7 times that at 80 lb., meaning pipe sizes only one or two commercial sizes larger. This concern was also purchasing power, the peak reaching more than 2,700 kw., or 3,600 hp. Besides this purchased power a large amount was obtained from non-condensing units.

This Plant Could Save $96,000 a Year

Space does not permit further discussion of the details except to say that, with purchased power costing one cent per horsepower-hour this firm could save about $96,000 a year by the use of byproduct power, after allowing for overhead and operating charges.

In any new power plants in those industries that use appreciable quantities of steam at pressures up to about 80 lb. the boilers would be designed for pressures practically equaling those employed in the latest central stations. This increase in pressure does not change the steam rate chargeable to byproduct power. This remains practically constant at 3 lb. per horsepower, a figure that no super-station could approach. The real purpose of increasing the pressure is to increase the amount of byproduct power that may be obtained from a fixed amount of process steam.

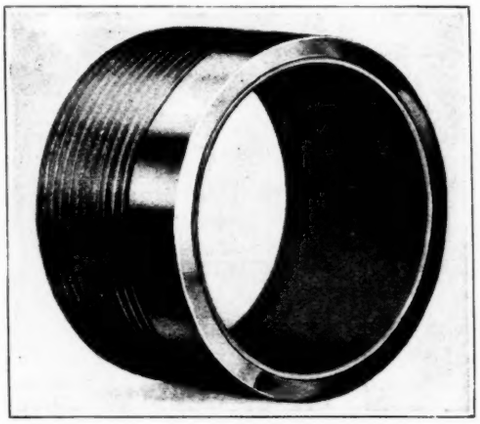
Of course it is to be remembered that the weight of steam per horsepower-hour handled with a high back pressure might be three to ten times the quantity of steam handled by a large condensing unit, meaning larger pipe sizes and larger pipe-radiation losses. But the blading of the non-condensing turbine would be much simpler and smaller since the density of the steam remains high. The size of the cylinder of a non-condensing steam engine, were it used, would for the same reason remain small. Again, there is an entire absence of the steam condenser, its auxiliaries and the cooling-water problem.

In a steam turbine, when from distortion, uneven expansion or other causes, the dummies are brought in contact with each other, a sudden high temperature is generated which may fuse the parts so heated. The usual result of heating a ring is to expand it, but in the local heating of the dummy rings the effect is the opposite of this, for when the dummies rub, the stationary ring closes in on the revolving shaft and produces a wedging action due to building up of the fused metal between the shaft and ring. This forces the shaft out of line, producing destructive vibrations or whippings of the shaft that may lead to loss of blades or even more serious results.

Materne Copper-Lined Pipe

In a certain large street-railway power plant the feed-water line was made up of 10-in. extra-heavy steel pipe. For a portion of its length this line ran over the top of the boilers behind the breeching, the hottest place in the boiler room. As the plant operated condensing, much of the feed water was condensate, which attacked the steel pipe and pitted it out every few months.

To eliminate this trouble, the plant finally called upon the Materne Manufacturing Co., of St. Louis, makers of large valves and fittings and contractors for power-plant piping. What was desired was a pipe line that would not corrode or pit under the severe operating



SEAMLESS DRAWN COPPER TUBING EXPANDED INTO STEEL PIPE

conditions existing. Lead- or tin-lined pipe was not considered suitable for high-temperature water, and it was thought that brass pipe would not be entirely satisfactory as it was liable to rupture and the cost would be high, Finally, it was decided to line the steel piping with seamless drawn copper tubing. An expanding device similar to a boiler-flue expander was made and the copper tubing expanded or spun into the steel pipe bringing the two metals into intimate contact. In the case referred to, the copper-lined pipe solved the difficulty and proved so successful that the company has continued to make it for feed lines and other services in the power plant, where the corrosion of steel piping is so rapid as to warrant the additional expenditure.

The Ljungstrom radial-flow turbine is arranged to admit steam near the shaft and expand through blading between two disks in a radial direction toward the circumference. Each successive row of blades is, therefore, of increasing diameter as it is displaced from the center. The first high-pressure blade row has a comparatively small diameter, while that of the exhaust blades at the periphery has the maximum diameter and therefore the greatest possible exhaust area. This gives practically an ideal distribution of blade area for the expansion of the steam. One of the large manufacturing companies has spent a great deal of money in endeavoring to develop practical turbines of this design, but commercial machines have never been produced in quantity in this country, which possibly may be accounted for by the extremely delicate construction required. Steam turbines for 500 lb. are now being built, and those for 1,000 lb. will probably be in operation inside of the next three years.

Improved Ellis Packless Trap

For a number of years the Ellis Drier Company, of Chicago, has been making a tilting trap of simple design, which has been offered for general use as a direct-return, lifting, vacuum or separating trap. The principles of operation are much the same as in other traps.

The Standard trap, as it is called, was constructed with glands at each end of the trunnion, and these glands were filled with soft packing which was pulled up with a follower and gland nut. When these glands were pulled tight enough to stop all leakage, there was a tendency in some cases to cause the trap to stick

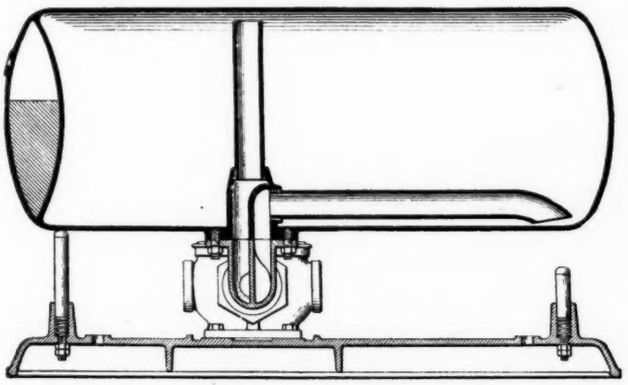


FIG 1—SECTIONAL VIEW OF THE ELLIS PACKLESS TILTING STEAM TRAP

or act sluggish. To eliminate this one bad feature, which is inherent in any tilting trap using glands with packing on the trunnion, the Packless trap has been developed. To all outward appearances it is the same as the Standard trap, but the glands have been eliminated and in their place are used metal-to-metal joints which are self-lubricating and have a device to provide for the expansion and contraction of the trunnion.

At either and of the trunnion the joint is composed of four parts, namely, the two halves of the point, a phosphor-bronze diaphragm and a spring. The half of the joint that is made a part of the trunnion stub contains an inserted self-lubricating metal ring; the other half is monel metal and is attached to the phosphor-bronze diaphragm. The outer circumference, or edge, of the diaphragm is held stationary against the body casting by a hexagon nut, while the center of the diaphragm to which the monel-metal half of the joint is attached, is free to flex backward or forward, depending on the expansion or contraction that takes place in the trunnion. The spring is used to maintain contact between the two halves of the joint when the trap is not in operation. Although the actual movement of the diaphragm on a 1-in. trap, due to expansion and contraction of the trunnion, is less than $\frac{1}{64}$ in., the movement would still be sufficient to cause binding if the diaphragm were not used.

As with the Standard trap, which was described in the July 27, 1920, issue of *Power*, one of the features is the placing of the counterweight inside the tank head. That is, a double head is welded into one end of the tank body and the space between the heads forms the receptacle into which is poured the necessary amount of lead to form the counterweight, the final adjustment being secured by adding shot after the lead has hardened. With neither external lever nor sliding weight the arrangement prevents tampering with the adjustment and the location of the counterweight produces rapid tilting action. When the trap begins to tilt, the center of gravity of the counterweight moves forward as it swings through its arc, thus shortening the counterweight lever arm, which in conjunction with a longer leverage at the other end of the trap accelerates the titling. With the tank returning to the horizontal position, the opposite action takes place. The center of gravity of the counterweight moves outward, lengthening the lever arm and causing the receiver to swing more quickly to place.

Another feature of the trap is the arrangement of the steam and vent valves, both of which are operated by a two-armed lever clamped to the end of the trunnion. By inclosing the valves as indicated in Fig. 2, operating levers, valve cages, gaskets, glands and packing have been eliminated. Each valve is operated at opposite periods in the cycle so that the full power of the trap is available to operate each valve. It is therefore possible to use a vent and steam valve of the same size and of large area, so that the trap will fill and vent with rapidity. Both valves are guided at the seat, and to insure proper alignment there is a guide in the valve cap for the stem.

As in the case of the Standard trap, the new design may be used as a direct-return, lifting, vacuum, separating or metering trap. In the vacuum trap a cold water spray in the trap tank is used. The cold water is controlled by a small valve which opens when the trap is in the filling position and closes when the trap tilts to discharge. When sprayed into the trap, the cold water condenses the residual steam left in the tank, producing a vacuum which draws the condensation out of the return lines. For a metering device the Packless trap is particularly adapted, as the friction on the joints remains constant and as a consequence there is no variation in the amount of water handled per dump. The Packless trap for each of the different uses indicated is made in nine different sizes.

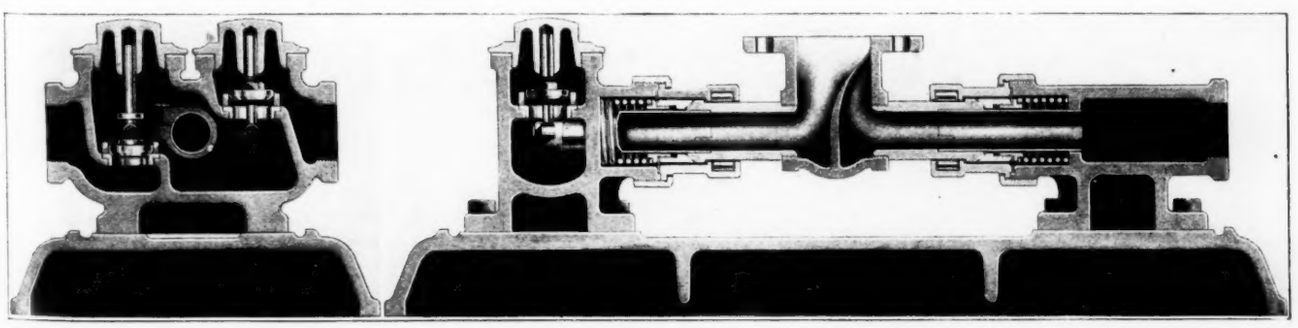


FIG. 2—SECTION THROUGH VALVE CHAMBER OF TRAP

FIG. 3—TRUNNION SECTION SHOWING PACKLESS JOINTS

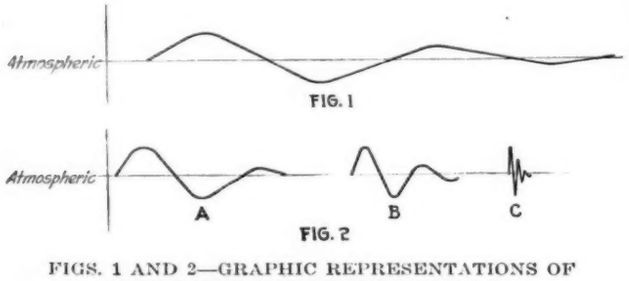
Conquering the Noise

By HIRAM PERCY MAXIM

THE principle employed in effectively silencing the exhaust of internal combustions was first employed by the author in developing a silencer for firearms. The results of these experiments are discussed and the construction of the exhaust muffler described.

WE SAY that an oil engine exhaust "thumps" or "drums" or "barks." We say that an air compressor intake "drums" or "snores" or "gasps." We say that a safety valve "hisses" or "roars." And we dislike such noises and the people responsible for creating them. What can be done to overcome them? The writer has given many years of study to this problem, and some of the things he has found may be of interest and value.

We need to go down to the bottom of things to get at this matter. We humans live and breathe and move about in an ocean of a substance known as air. We are not unlike the crabs and crawling things on the ocean bottom, inasmuch as we move around upon the bottom of a great ocean. This air pervades us completely, just as the water pervades the crab and the fishes. Any disturbance in the way of a shock or jar is quickly transmitted to us. We have grown special organs to detect these air shocks or disturbances, and we call these organs "ears." When we examine the mechanism of this queer little ear, we find that it is a transmitting system, connecting with the brain, and that it possesses certain fixed limitations. These limitations are different from the limitations of other animals which also possess these ears. But since it is only with human ears that we are concerned, we will confine our study to those disturbances which occur within their limitations.



FIGS. 1 AND 2—GRAPHIC REPRESENTATIONS OF INAUDIBLE AND AUDIBLE SOUNDS

The human ear will record upon the brain what we call a sound, when the "rate of suddenness" with which the air is disturbed exceeds a certain value. Below this value no sound reaches the brain. Above this value a sound cannot be avoided. If a whip is moved through the air gently, the most sensitive human ear cannot detect any sound. It is, of course, creating a disturbance. If it is moved more briskly, we call it a "swish" or a "whir." If we increase the briskness, the sound becomes louder. It will become what we call "vicious." Just beyond this "vicious" point, and especially if the whip has a lash on its outer end, the sound becomes a sharp "crack." We call it "cracking a whip." This sharp, explosive "crack" marks another limit of the human ear. Whenever any material substance acquires a velocity in excess of the velocity of sound, this sharp "crack" occurs. A bullet from a high-power rifle makes this "crack." No matter how perfectly we silence the report of a gun, we have this bullet "crack" if the velocity of the bullet exceeds approximately 1,100 feet per second. Only firearms giving bullet velocities below 1,100 feet per second can be made to shoot really quietly.

Photographs of this "crack" have been made, and a study of them is of great value in the study of other discharge noises. They will be referred to later.

If we were to show graphically the characteristics of the human ear, we would draw up curves such as Figs. 1 and 2.

Fig. 1 shows an "inaudible sound." It seems like a queer kind of a sound, but it expresses what we mean

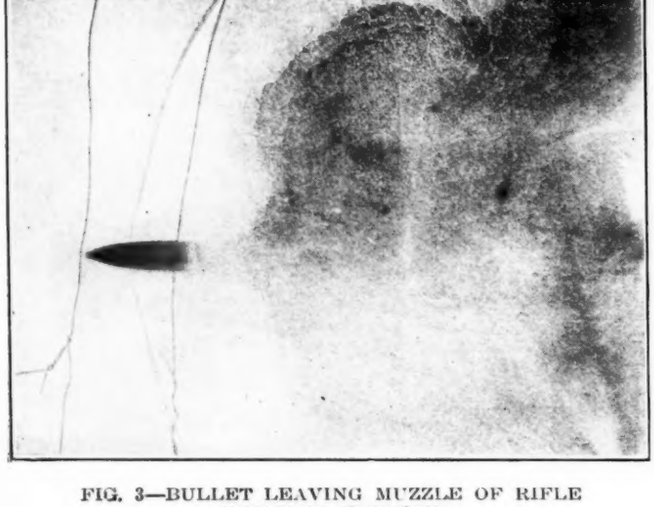


FIG. 3—BULLET LEAVING MUZZLE OF RIFLE WITHOUT SILENCER

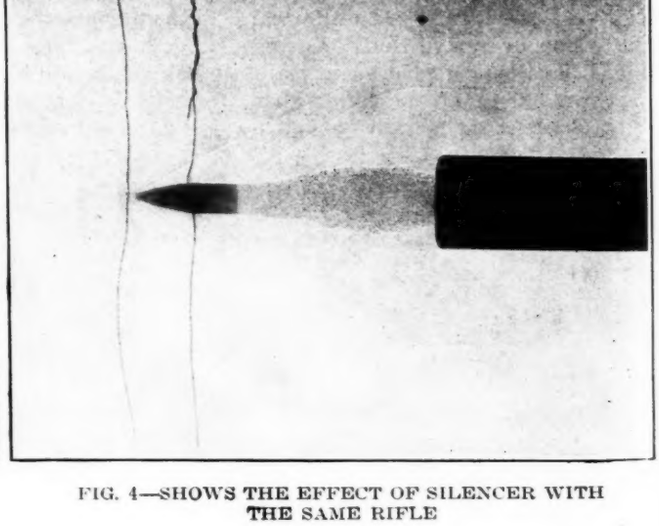


FIG. 4—SHOWS THE EFFECT OF SILENCER WITH THE SAME RIFLE

exactly. It represents a gradual rise of air pressure as a result of some kind of disturbance or push against the air. Probably the word "push" describes the disturbance, as against the word "blow." A gentle push is conceived as a gradual building up of pressure. A blow is conceived as a sudden impact. In the curve the air pressure gradually rises and gradually falls and gradually dies out. It represents a "rate of suddenness" which is below audibility.

Fig. 2 at *A* shows a sound which is just sudden enough to be audible. At *B* the suddenness, or rate of

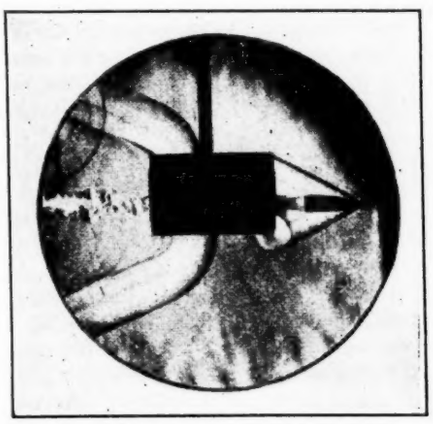


FIG. 5—ILLUSTRATES EFFECT OF SHOOTING BULLET THROUGH A TUBE

rise of pressure, is greater, and a sharper character is imparted to our ear. This sharpness increases the audibility. The sound will travel farther and still be detected. At *C* the suddenness has reached a degree corresponding to the crack.

This establishes some of the basic principles so that we may understand what is to come.

Thanks to the fortunate fact that air refracts light at varying degrees according to the air pressure, we are able to take photographs of sounds. A few moments' reflection over some of these interesting photographs will help us grasp the mechanics of an exhaust noise from an oil engine.

Fig. 3 is a reproduction of a photograph of a bullet leaving the muzzle of a Springfield caliber .30 Army rifle. The heavy report noise is the heavy circle just outside the cloud of powder gases. This noise, originated by the sudden release of the high-pressure gases and the blow they struck against the air, is advancing at the velocity of sound, that is, 1,100 ft. per sec. The bullet, traveling at over 2,700 ft. per sec., is getting ahead of the report wave. The bullet "crack" noise is seen enamating from the point of the bullet. Thus both noises are shown, and it will probably be news to many that there are two separate noises when a gun is discharged. It will very likely still further surprise them to know that there are two separate and well-developed noises in many exhausts and suctions.

Fig. 4 shows the effect on the same rifle when a Maxim Silencer is installed. The bullet flight noise is clearly shown, and a searching examination of the original photograph fails to disclose any report noise. The gases, in fact, are clearly shown emerging relatively gradually from the silencer.

Fig. 5 continues the series. With the report noise eliminated, we may study undisturbed the clean-cut bullet noise. The picture shows the result of shooting through a tube. This picture will bear close study, for it shows clearly the way a sound wave progresses around obstructions. Note how the sound is intercepted by the solid portions of the wall of the tube, and how it issues and turns the corners at the ends. Having no inertia, this sound wave, or zone of compressed air, can advance and change direction independently of centrifugal force.

Let us now take up the "thump" or "bark" of the oil-engine exhaust. Although the air-compressor "snore" and the safety-valve "hiss" will not be considered here, what is said of the oil engine will help in a study of the others.

A large Diesel oil engine running at approximately 180 r.p.m. lifts its exhaust valves at a certain "rate of suddenness" to use this rough but expressive term. This means that the blow struck the air by the released gases is of a certain degree of suddenness. These large slow-moving engines are said to "thump" or "drum." A smaller engine will run faster. The rate of suddenness of the lift of its valves will be greater than it was with the large engine. Such fast-running engines are said to have a "savage bark."

Two-stroke-cycle engines usually exhaust by uncovering a port. The area of this port is always great, and since the piston is moving fast enough, even near the end of its stroke, to give a big release almost instantly, a very sharp blow of great energy is struck the air. We say that such engines "crack unmercifully." Small two-stroke-cycle motor-boat engines, with their small ports and consequent high speed, give the sharpest, snappiest crack of all.

Photographs of these various kinds of exhaust noises are not yet ready for publication, but it can be said that for the purposes of this study these noises have the same characteristics as the gun noises. There are two separate noises, just as in the gun, one of them being the big booming air shock resulting from the release of a large mass of gas, and the other the "high-tension" noise created at the valve seat, when the jet of escaping gas had a velocity in excess of the velocity of sound. This is the crack part of the noise, and as has been explained, the proportions of a crack in an exhaust vary with different kinds of engines. In big, slow-moving four-stroke-cycle Diesels it is small and

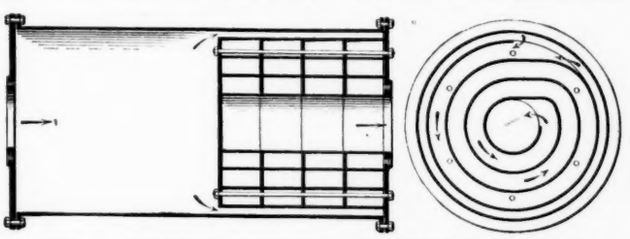


FIG. 6—SECTION THROUGH EXPANSION CHAMBER

most of the noise is what corresponds to report noise. In small, two-stroke-cycle, port-exhaust engines, it is large and the report element is small.

In considering means for silencing these exhaust noises, one important matter to keep in mind is that thing which we call back pressure. But before starting to make provision for it, let us take a close view of it.

"Back pressure" in internal-combustion engines really means to engineers a failure to empty out the old burned gases completely. If they are not completely emptied out, they cut down the quantity of fresh charge that can be drawn in, and in addition interfere with the burning qualities of the fresh charge. Engi-

neers have formed the habit, probably because of steam engine practice, of measuring the degree of this emptying by taking the pressure inside the exhaust line in pounds or ounces per square inch or inches of water or of mercury. The first thing we find in taking these pressure readings, is that the intermittant exhaust causes violent swinging or fluctuating in the measuring apparatus. To damp this swinging so it can be read, we throttle something. Then we say we get the "average back pressure."

The facts are that this system may or may not indicate the truthful average back pressure. What one

FIG. 7—SHOWS FORM OF INTAKE SILENCER

is really interested in, after all, is fuel consumption, power output and smoothness of running, and carbon deposit in the cylinders, in many cases. All these are better the more completely the cylinder is emptied of the burned gases, and if there is any question about the accuracy of the method of indicating this "emptying," then we had better limit ourselves to the engine performance points mentioned. In any event, it is well to jump over controversial details by thinking in terms of emptying and not of "average back pressure."

The four-stroke-cycle engine devotes an entire stroke to exhausting. Not only is the pressure inside the cylinder released, but the burned gases are actually mechanically pushed out by the piston. All that is left in is what can be held in the compression space. Obviously, there is plenty of time for the exhausting to be done.

In the two-stroke-cycle engine only a very small portion of the stroke is allotted to the exhaust. As the piston almost reaches the end of its stroke, it uncovers a port effecting the release of the exhaust. Immediately, after a very short interval of time, the air for the next stroke is admitted. The hope, of course, is that this fresh air, or charge, will not mix with the old burned gas, but will push out the latter and will not push out too much of itself while doing so. Things are a bit left to chance.

This brings us to the point we have been leading up to. Emptying of the four-stroke-cycle cylinder would never be complete, even if the average back pressure was atmospheric. There would always be the gas left in the compression space. Emptying of the two-stroke-cycle cylinder would never be complete, because the whole scheme of things is hit-or-miss. Some of the old burned gases would surely mix with the fresh charge, and some of the latter would be sure to pass out the exhaust with the exhaust gases. Average back pressure throughout the period of the exhaust does not mean much. In fact, we do not much care what the back pressure is at any stage of the exhaust period but one. It is only at the very end of the exhaust period that pressure in the exhaust line cuts any figure, so to speak. That is when the exhaust closes and imprisons what has been left inside. Therefore, it is only important that the so-called back pressure be low just as the exhaust valve or port closes. That is where we should focus our attention.

The writer has spent many weary hours trying to lower by a few inches of water the pressure in an exhaust line at the instant or just before the instant the exhaust closes. Naturally, if one could devise a silencer that would conquer the noise of an exhaust and "suck" just a little at this critical moment, one would be accomplishing something that would be worth while.

Principle of Long Pipe Employed

It is generally recognized by those who have worked in the oil-engine field that a long and straight exhaust stack, or outlet tailpipe, has quite a healthy "suck" or "draft." The reason for this is that the long column of gas inside the pipe, once it has acquired motion, tends to persist in this motion. The inertia of the gas, in other words, produces a pull, or depression at the bottom of the pipe, if this bottom is suddenly closed after the gas had been put in motion. Here is a mighty significant thing to the silencer designer. If a silencer could be built that would combine those noise-damping qualities which were necessary, and the features of the long pipe, it would fill the bill. It was but a simple step to think of coiling this long exhaust pipe, so it could be stowed inside a relatively small space. Since it had previously been discovered that an effective silencing action can be got from a passageway which is ever changing in direction and has a cross-sectional extent small with relation to its length, it was but another step to think of dividing the coiled up pipe and making of it several smaller pipes or channels. Reference will now be made to Fig. 6.

It is apparent that there is an expansion chamber, whence the exhaust may find a quick release and, incidentally, where solid matter carried over may collect and be easily removed. Attached to the outlet head are several coils, or what amounts to such. These consist of iron castings having spiral or concentric channels. They provide a long passageway, leading from the outer circumference and gradually working down to a delivery at the inner hole. There are enough of them to provide whatever degree of silencing and pulling is necessary. The greater the mass of gas in the coils, the greater the pulling capacity, provided certain limits set by skin friction are not exceeded. The longer the coil, or channel, the greater the mass of gas and the better the silencing effect. The combination, in other words, is a happy one. Such a silencer can be made to render the exhaust of the worst offenders in the two-stroke-cycle line all but inaudible, and where the exact requirements have been met, it will pull sufficiently to give actually a suction charge in excess of the piston displacement.

There is one other interesting form of silencer that should be mentioned before closing. This is the type that had to be developed for certain intakes. The conditions are quite different from an exhaust. The character of the noise is different, among other things. This silencer is shown in Fig. 7.

The channels in this construction are formed by con-

centric rings. Ports provide connections between the different channels, but these ports are not opposite. A sound wave and any pulse of a mass of gas divides when entering the outermost port and takes both ways around to the outlet on the other side. One of these paths is shorter than the other. Hence, one half of the wave or pulse arrives slightly ahead of the other half. A division into two has occurred.

In entering the second port, another division occurs to each division already made. There are enough of these channels to give a total division into sixty-four parts. Obviously, the noise is reduced to one-sixty-fourth, and in addition, whatever results from the ever-changing wave front. Any heavy mass pulse becomes stretched out, so as to introduce the element of time and thus cut down "suddenness."

As may be imagined, this account covers a very small part of the noise field which has been studied. The writer can say, in concluding this rather sketchy survey of exhaust noises, that he feels he is justified in claiming that the day will come when we shall find it possible to conquer all forms of troublesome noises. The value of peace and quiet is tremendously greater than many of us believe.

New Uehling Combined Barometer and Vacuum Recorder

The Uehling Instrument Co., Paterson, N. J., has recently developed a new combined barometer and vacuum recorder primarily for determining and recording (1) the absolute back pressure in steam turbine and condensing plants, (2) the barometric pressure, (3) the condenser vacuum, (4) the existence of air leakage into the condenser and the ability of the condenser to handle the load.

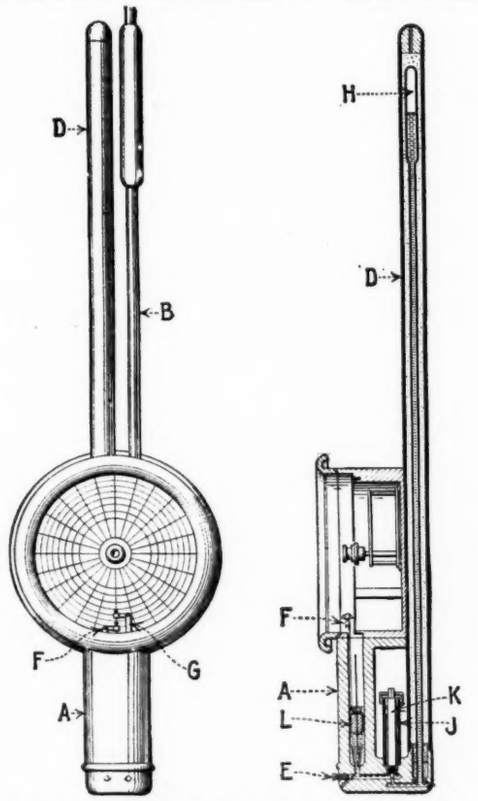


FIG. 1—EXTERIOR AND SECTIONAL VIEWS OF INSTRUMENT

An exterior view of the complete instrument and a sectional view of the barometer side (construction of the vacuum side is similar) are shown in Fig. 1. The recorder consists essentially of two float chambers contained in the float vessel *A*. One float chamber is connected with the barometric mercury column *D* and the other with the mercury column B that is in communication with the condenser. The pens *F* and *G* are actuated by means of floats resting on the mercury in the two chambers, the surface of the mercury being protected by a film of oil. The movements of the floats correspond to the changes in barometric pressure and in vacuum. The mercury vessel *J* and plug *K* are a means provided for calibrating the instrument.

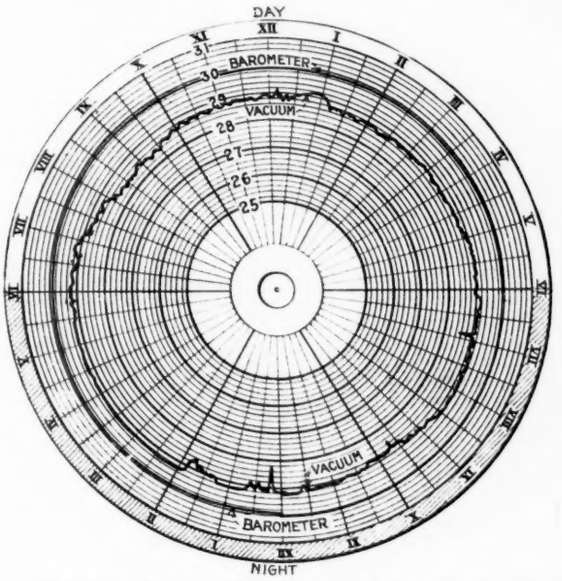


FIG. 2—REPRODUCTION OF RECORDER CHART

A reproduction of a recorder chart is shown in Fig. 2. The recorder draws automatically and continuously, the barometer and vacuum lines on the same chart. The barometer record is used as a base line for reading the absolute back pressure directly off the chart.

Since under normal operation the two lines drawn on the chart would vary simultaneously and proportionately, any unusual change in the vacuum line immediately indicates to the engineer an impairing of the vacuum due to air leakage, shortage of circulating water or other causes.

The instrument records any part of the total range of 0 to 31 inches. Vacuums from 25 to 31 in. and the corresponding absolute back pressures are recorded over nearly the full face of the chart, the rest of the chart being used for recording on a contracted scale the lower vacuums down to atmospheric pressure.

In making the illustration showing the application of a deflection-measuring device to the shaft of a vertical engine with overhung flywheel, in Mr. Shepherd's article on page 363 of the issue of March 6, the artist unfortunately chose the Anderson engine as the model for his sketch. The builders of that engine naturally resent the possible inference that the awful example there described was one of their shafts. As will be apparent to any reader of the article, it was not an Anderson shaft, nor the shaft of any other modern engine, that was the subject of the experiment.

Starting Direct-Current Motors—Current-Limit Type Controllers—II

BY CHARLES A. ARMSTRONG

THE principle of three types of series-lock contactors is explained and the operation of motor controller using these types of contactors is discussed.

CONTACTOR switches as used on electric-motor automatic controllers may be divided into three general classes—shunt, series and compound—according to the ways in which their coils are connected. In the shunt type the coil is connected across the line either with or without a series resistance as conditions may require. A series contactor is one that has its coil connected in series with the motor, and a compound contactor is one that has a shunt and series coil. It is with the series type of contactor that this article will deal, particularly that class known as the series-lockout type. The series-lockout principle has been used by a number of manufacturers of controllers, two types of which were explained in an article in the March 13 issue.

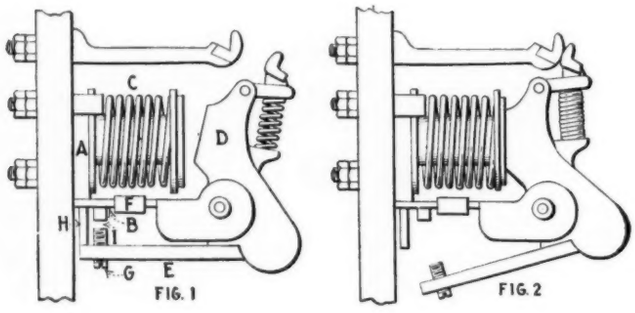


FIG. 1

FIG. 2

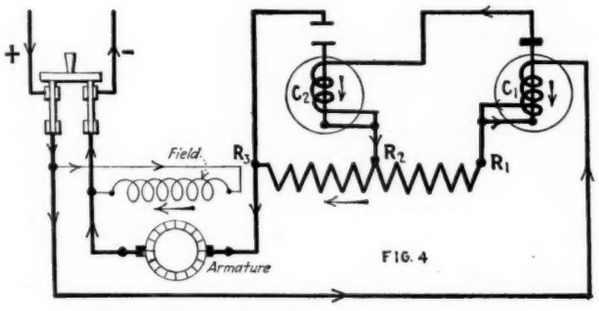


FIG. 4

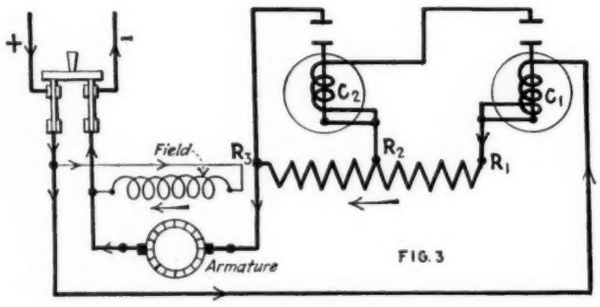


FIG. 3

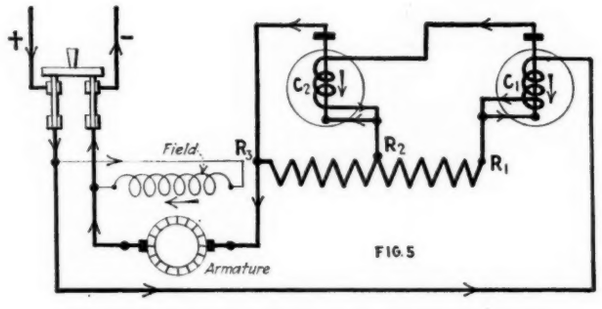


FIG. 5

FIGS. 1 TO 5—DIAGRAMS OF WESTINGHOUSE SERIES-LOCKOUT TYPE CONTACTOR AND CONNECTIONS

Although the fundamental principle is the same in all series lockout-type contactors, the variation in construction may make any particular type's operation somewhat obscure to the uninitiated. Figs. 1 and 2 indicate the operation of a series-lockout type contactor as used by the Westinghouse Electric & Manufacturing Co. In this type only one coil is used, which sets up a magnetic field that holds the contactor open when the inrush current exceeds a predetermined value and closes it when the current decreases below a certain value. The contactor is locked open by using a copper loop around part of the magnetic circuit to choke the lines of force back and cause them to be shunted into a path that creates a pull to prevent the contactor from closing. When coil *C* is energized, it causes a flow of magnetic flux that tends to take the path *ADB*. However, part of the flux is prevented from doing so by the copper loop *F*, which completely surrounds section *B*. As the lines of force tend to increase through *B*, loop *F* has a current induced in it similar to the secondary of a transformer, which will flow in a direction opposite to that in coil *C* and consequently oppose an increase in the magnetic flux through path *B*. The choking action of the loop *F* causes part of the flux to pass through the tailpiece *E* and adjustable plug *G* to *B* and *A*. This creates a pull across air gap *I* which tends to hold the contactor open. When the inrush current is above a certain value, the pull across air gap *I* will be high enough to hold the contactor open. As the current decreases in value when the motor increases in speed, two things happen. The choking effect of loop *F* decreases and allows more of the lines of force to pass through *B* and, as a result, less of the lines pass across air gap *I*. The latter decreases the pull that tends to hold the contactor open, and when the current has decreased to a predetermined value the contactor closes as in Fig. 2. In Fig. 1, *H* is a piece of non-magnetic material to prevent air gap *I* from closing.

Adjustments of the contactor can be made for the current values at which it will close by turning the threaded iron plug *G* up or down. The shorter air gap *I* is made, the greater the number of magnet lines will flow from *G* to *B* and the lower the current value

required to lock the contactor open. On the other hand, the longer gap *I* is made the smaller the number of magnetic lines that will pass into *G*, consequently the smaller the pull tending to lock the contactor open. Thus a long air gap at *I* will allow the contactor to close at a higher current value in coil *C* than with a short air gap.

Figs. 3 to 5 show diagrams that indicate the operation of a controller equipped with contactors as described in Figs. 1 and 2. With the line switch closed as in Fig. 3, current flows through coil C_1, the starting resistance R_1R_3 and the armature to the — side of the line. The shunt field is connected directly across the line. Contactor C_1 is locked open by the inrush current, but as the motor increases in speed this current decreases in value and the contactor closes, as in Fig. 4. With contactor C_1 closed, the circuit is through coil and contactor C_1 and coil C_2 to R_2 and R_3, the armature and to the — side of the line. This cuts out the section of resistance between R_1 and R_2 and allows the starting current to increase in value again, which locks contactor C_2 open. As the armature increases in speed, the current decreases to a value that closes contactor C_2 and cuts out the remaining section of resistance as in Fig. 5. This connects the armature directly across the line and it comes up to full speed. Although the armature current flows through coils C_1 and C_2, it cannot be depended upon to hold the contactors closed, for if the load was removed from the motor, the current might decrease to a value that would allow the contactors to open. To take care of this contingency, the last contactor to close is usually made of the counter-electromotive force type, and when this closes it cuts the series contactors out of circuit as well as the last section of starting resistance.

Another type of current-limit contactor is that used by the General Electric Co. and is shown in Figs. 6 and 7. When coil *C* is energized by the motor current, magnetic lines are caused to flow through two paths, one down through core *B* to *E* and through *D*, armature *A* and back to *B*. Section *D* is of small cross-section so that it can carry only part of the flux set up by the inrush current in coil *C* and is also surrounded by a copper shroud *I* which acts to choke back the flux, as explained in Figs. 1 and 2. The excess flux passes through the adjustable iron nut *F*, across air gap *G* to *H*, around through *A* into core *B*. The flux passing into *H* creates a pull opposing that between *A* and *B* and holds the contactor open until the current has decreased to a value where most of the flux is passing through *D*. Under this condition the pull across air gap *G* has

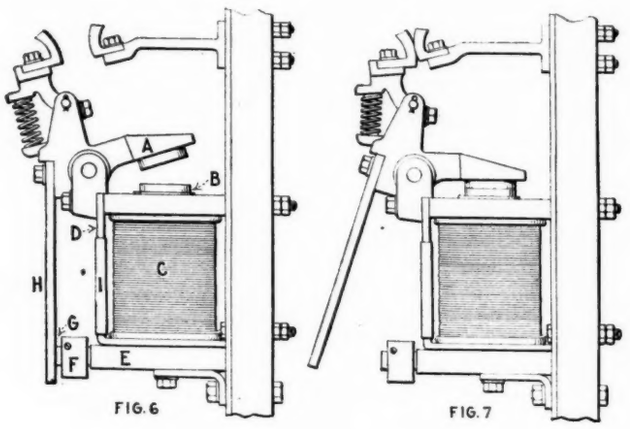


FIG. 6

FIG. 7

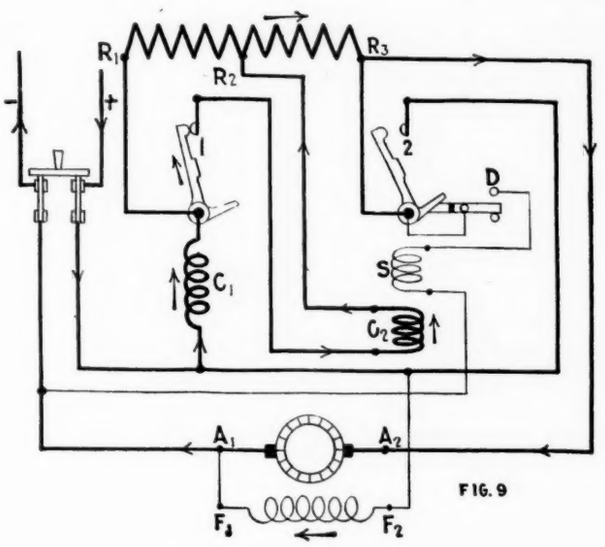


FIG. 9

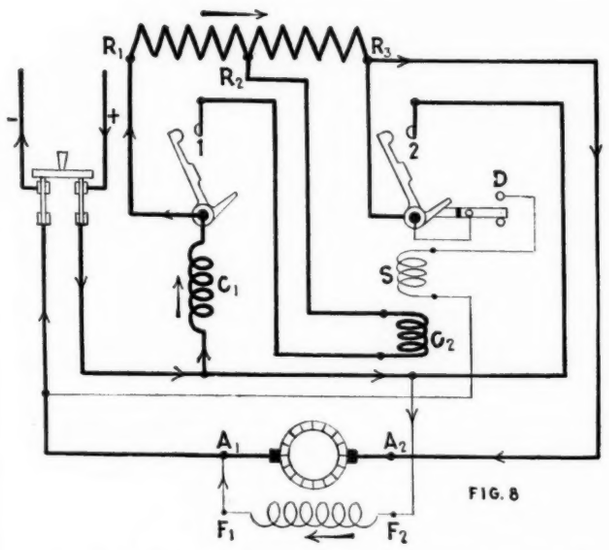


FIG. 8

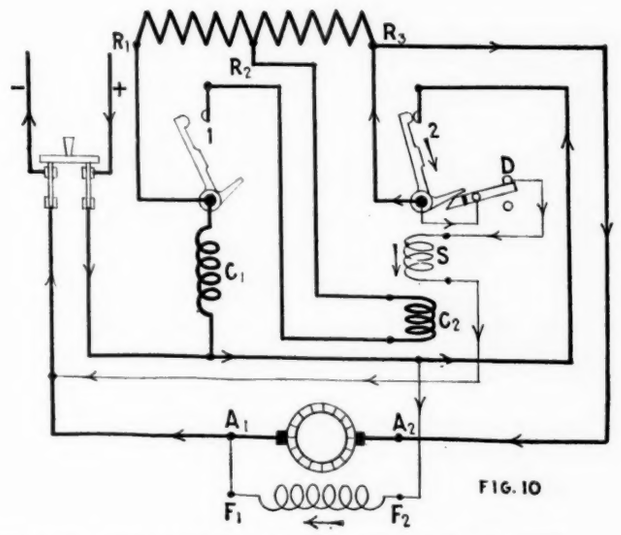


FIG. 10

FIGS. 6 TO 10—DIAGRAMS OF GENERAL ELECTRIC SERIES-LOCKOUT TYPE CONTACTOR AND CONNECTIONS

decreased to a value that allows the pull between *A* and *B* to close the contactor, as in Fig. 7.

Adjustment of the contactor is made by changing the position of nut *F* on its stem. This nut is threaded on an extension of *E* which has a non-magnetic plug in its end against which *H* rests when the contactor is open. By bringing nut *F* nearer to *H*, air gap *G* will be decreased, and for a given current in coil *C* a greater

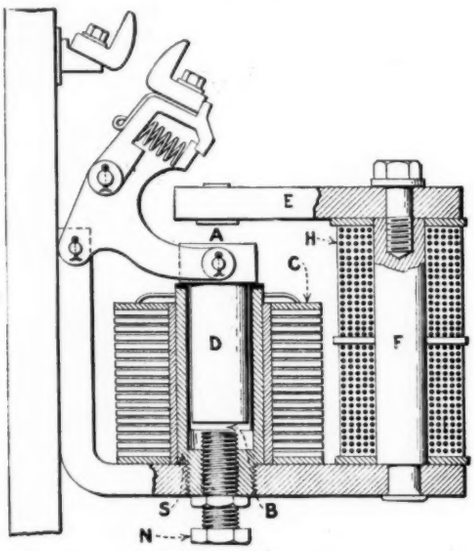


FIG. 11—SERIES-LOCKOUT TYPE CONTACTOR HAVING A SERIES AND A SHUNT COIL

number of magnetic lines will pass from *E* to *H*, consequently increasing the pull tending to hold the contactor open. The farther nut *F* is away from *H* the smaller will be the number of magnet lines across air gap *G* for a given current in coil *C*, therefore the smaller the pull tending to hold the contactor open, and it will close at a higher current value than when air gap *G* is short. The adjusting nut never should be screwed out so far as to touch *H*, or the contactor may not close at any current value. The contactors can be adjusted to hold open at any current value between 200 and 75 per cent of the coil rating. The lowest operating current is about 33 per cent, and the drop-out current is 10 per cent.

Figs. 8 to 10 show diagrams of a controller having contactors that operate on the principle explained in Figs. 6 and 7. When the line switch is closed, a circuit is completed through coil C_1, the starting resistance R_1R_3, through the armature and to the — side of the line. The field winding is directly connected across the line. When the armature circuit is closed, the inrush current causes coil C_1 to lock contactor No. 1 open, as previously explained. As the armature increases in speed and the current decreases to a predetermined value, contactor No. 1 closes as in Fig. 9. The circuit is now through coils C_1 and C_2, through the section of starting resistance between R_2 and R_3, through the armature to the — side of the line. Cutting out the section of resistance between R_1 and R_2 causes the starting current to increase and coil C_2 locks contactor No. 2 open. This causes a further increase in the motor's speed, and when the current again decreases to a predetermined value, contactor No. 2 closes and cuts all the starting resistance out, as in Fig. 10. Coils C_1 and C_2 are also cut out of circuit and the holding coil *S* cut in, as indicated. Where the load on the motor will not decrease below 10 per cent of full-load value, the closing coils can be depended on to hold the contactors closed and the holding coil *S* need not be used.

The series-lockout type contactors, previously described, will close on currents ranging from what is known as the calibrating value (that is, the lowest value at which the contactor will lock open for a given adjustment) down to about 30 per cent normal rating. If for any reason the current does not exceed about 30 per cent normal rating, the contactor will not close and the armature resistance will remain in the circuit. If a load comes on the motor, its speed will decrease until the current reaches a value that will cause the switch to close, when the resistance will be cut out and the speed increased. To overcome this objection, a series-lockout type contactor having two coils has been developed by the General Electric Co., a diagram of which is shown in Fig. 11. On the contactor there is a shunt and a series coil, both of which act on the magnetic circuit *DEF*. Should, for any reason, the series coil fail to close the contactors, when energized with a current below the calibrating value, the shunt coil will insure closing.

Considering the action of the series coil alone, the operation of the contactor is similar to those previously described. When the armature circuit is closed, the inrush current through the series coil *C* set up a flux through the magnetic circuit *DEF*. The magnetic sleeve *S* is so proportioned that when the current exceeds a predetermined value it becomes saturated and magnetic lines are caused to flow through plug *N*, across air gap *B*, and create a downward pull on movable core *D*. All the flux passing into core *D* goes across air gap *A* and creates an upward pull tending to close the contactor. When the current exceeds a given value, the pull between *D* and *N* plus the weight of *D* is greater than the pull between *D* and *E*, therefore the contactor is locked open. As the motor increases in

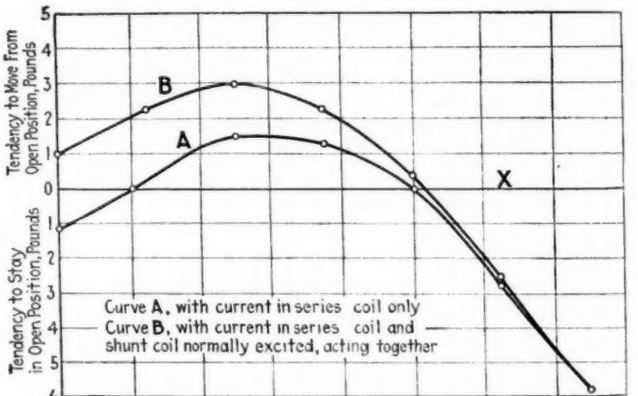


FIG. 12—CURVES SHOWING THE CLOSING AND LOCKOUT FORCES ACTING ON CONTACTOR FIG. 11

speed and the current in coil *C* decreases, the flux in the magnetic circuit decreases, likewise the pull across the gaps *B* and *A*. However, the pull across gap *B* decreases faster than that across *A*, and when the current has decreased to a given value the difference between the two has become great enough to close the contactor.

On account of the saturation characteristics of the magnetic circuit the pull locking the contactor open is

about the same with the shunt coil as without it, as can be seen from the curves, Fig. 12. Curve *A* represents the pull in pounds acting on core *D*, Fig. 11, due to the series coil *C* alone. Where line *X* cuts the curves, the forces acting on the movable core neutralize each other; that is, at 20 and 100 per cent full-load motor current the contactor has the same tendency to stay open as it has to close. Beyond 100 per cent full-load current the pull tending to hold the contactor open exceeds that tending to close it. At 150 per cent current the contactor is being held open by a pull of about six pounds. Between 20 and 100 per cent full-load current curve *A* is above the line showing that there is a positive closing pull acting on the contactor. When the current drops below 20 per cent in the series coil, the curve is below line *X*, showing that the resultant force acting upon the contactor will prevent its closing. In practice the weight of the bell crank of the contactor connecting it to core *D* will cause failure to close at about 30 per cent full-load current instead of 20 per cent shown on the curves.

Curve *B* shows the pull exerted on core *D* by both the shunt and series coils. When the motor current at starting exceeds 100 per cent full load, curves *A* and *B* practically coincide, which shows that as far as the lockout characteristics of the contactor are concerned they are about the same for the series coil alone as for both shunt and series combined. However, below 100 per cent full-load current the pull is always a positive one; even when the current in the series coil has decreased to zero, there is one pound effective pull to close the contactor, so that it can be depended upon to close at any value below the minimum lockout value.

In the curves 100 per cent full-load current has been assumed as the value to which the inrush current must decrease before the switch will close. This value can be changed by adjusting plug *N*, Fig. 11. The closer *N* is brought to core *D* the greater will be the flux passing through gap *B* for a given current, consequently the smaller the current required to lock the contactor open. The longer gap *B* is made the smaller the number of lines of force passing from *N* to *D* and the higher the current value required to lock the switch open. Adjustments can be made so that the contactor will lock open on 75 per cent rated current and above in the series coil and close at current values below 150 per cent as the highest closing range. Another feature in the design of this contactor is that it acts as a reverse-current device and opens with a certain value of reverse current in the series coil.

In the April issue of *Mechanical Engineering*, a report of tests run on a Scotch marine boiler by the United States Shipping Board in conjunction with the Bureau of Mines, demonstrates the possible efficiencies that may be obtained with this type of boiler. The unit was a single-ended, three-furnace, separate combustion-chamber type, having 2,777 sq.ft. of heating surface with coal fire and 3,022 sq.ft. with oil fire. It was fitted with a 774-sq.ft. waste-heat superheater, placed in the gas pass above the smokebox and above this a 1,220-sq.ft. air heater, which heated the air to the Howden fronts when running forced draft. The tests were divided into four groups: Hand-fired coal, pulverized coal, forced-draft oil fire, and natural-draft oil fire. The best results were obtained with the forced-draft oil fire, where the average of three tests shows a boiler efficiency (without superheater) of 81.77 per cent.

Boiler Inspecting—VII

By James F. Hobart

THIS article, the last of the series, deals with the internal inspection and describes the method of testing and adjusting the gage.

HAVING finished the inspection of the back end of the boiler, the inspector should work his way toward the front, and he should examine the upper portion of the boiler as he crawls along. He should take another look at the manhole reinforcing ring and at the openings to the pop valves. The law in many states requires that two safety valves be attached to each boiler, perhaps each with a separate opening, but sometimes both valves are placed over one opening as will be described later.

The inspector should watch for discolored spots in the shell and hit them with the hammer. Sometimes a bad defect is located when one of these spots is investigated. He should take another look at the feed pipe as he crawls over it, to see that it is properly suspended so as not to rub against the tubes. It should be wired or otherwise suspended in the steam space. This is sometimes done by supports clamped to a couple of the outside tubes.

Watch for Tube Wasting and Pitting

There may be tube wasting and pitting at front end as well as at the rear of the boiler, but that defect is less likely to be found at the front end. The inspector should, however, watch for it everywhere. He should examine closely the water-column connections and determine if the openings are clear. He should look over the front head about the same as he did the rear one, note any incrustation or scale and look closely at the braces and the manner of their fastening to the head and shell, also test each brace with a hammer for looseness or undue strain. He should see the condition of each pin or rivet head and of those in the angles if angle-iron bars are used.

Use the wire to let the candle down among the tubes at the front head and note the condition of them. Test the tubes with the hammer as far down as possible and work as close to the tube sheet as possible in order to find any wasting that may have taken place there, on the tube sheet or on the tubes. Look out for local wasting, also for a general thinning of the sheet between the tubes. Such thinness is hard to detect. Sometimes, where there is suspicion of it, the inspector will order a tube removed so that he can make actual measurement of the tube sheet thickness.

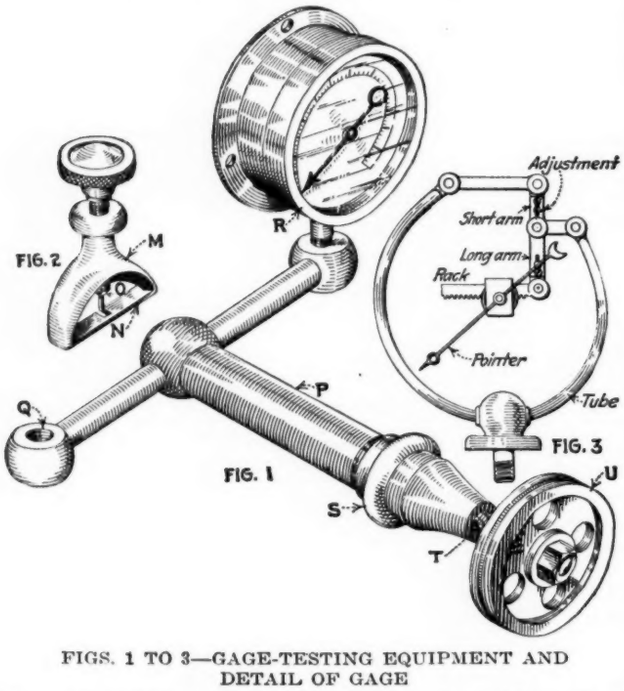
While the inspector is working his way back to the manhole, after completing the internal inspection, he should take a final look at the shell and tube surface. When ready to leave the boiler, see that the tools, and piece of board are put out and nothing is left behind. It is well that an attendant should always be within call when an inspector is in a boiler, to give aid if necessary.

With the tools all out of the boiler the inspector should stretch up his hands, pull his feet underneath him and wiggle upward through the manhole. When some boilers with small manholes are to be entered, the writer has found it occasionally necessary to remove all his clothing but the combination suit, in order to get his body through the manhole. Getting into a boiler is easy enough, but getting out is sometimes

quite difficult, as owing to the heat of the boiler and perspiration, which seemingly enlarges the body, it is often difficult to get out. In a case of this kind the inspector should keep calm, take his time and work his body gradually through the manhole.

Safety Valves Need Attention

Take another look at the safety valves after coming out of the boiler. As previously stated, the law in most states requires two valves. They may both be placed upon a single Y-fitting, but there must be no valves of any kind between them and the boiler and no undue length of pipe either. The waste pipe, if any, must be of the same diameter as the safety valve, and no stop or other valves should be placed therein, and the pipe must be so disposed that it cannot freeze in



FIGS. 1 TO 3—GAGE-TESTING EQUIPMENT AND DETAIL OF GAGE

Fig. 1—Gage tester. Fig. 2—Jack for removing pointer. Fig. 3—Gage mechanism, showing means of adjustment.

cold weather. A drip pipe must also be connected thereto, close to the safety valve, in such a manner that all water that finds its way through the safety valve will be drained readily from the pipe.

Next remove the steam gage and place it on the test pump shown in Fig. 1. This tool consists of a hollow barrel *P* into which is fitted a watertight plunger. The plunger, which carries a leather cup packing, is fastened to the screw *T* which acts as a plunger rod for the instrument. By turning the wheel *U*, the plunger is moved back and forth inside of the pump barrel *P*.

Two arms are built solid with the barrel *P*, one of them for the attachment of the test gage *R*, the other for the gage to be tested. The engineer should have at hand a few ¼-in. and ⅜-in. fittings so as to be able to make connection with any gage easily, no matter whether it terminates with a nipple or with a tapped connection. Usually, these testers are made with a plug stop valve in each of the arms, so that either or both gages may be shut off as desired when the required pressure has been reached. By shutting off the gages, it may be determined whether they lose pressure through leakage in any part. To test a gage, attach it airtight to the opening *Q*, unscrew the cap *S* and remove the plunger from the barrel *P*, which should be filled with water and the plunger replaced therein, after screwing the rod *T* out as far as possible.

After the cap *S* has been replaced and screwed fast, see that the plug valves, if any, are fully open between the barrel *P* and both the gages; then turn the handwheel *U* until the desired pressure has been reached and proceed to test the gage. Great care should be taken that the test gage *R* is always accurate. In order to be sure of this the engineer should occasionally have it tested against a mercury column by some boiler-insurance concern. Run the pressure up and down by means of the screw pump and watch the gage and compare it with the test gage. If the gage stands "heavy," that is, if the pointer does not read to zero, set the pointer back and it may indicate properly. But to do this, it is first necessary to remove the "pointer" from its spindle. A "jack" for this purpose is shown in Fig. 2. The slotted cross bar *N* is slipped under the hand to be removed, then the "jack" is so adjusted that the screw *O* is brought against the end of the pivot upon which the hand is located. The screwing down of *O* pushes the pivot out of the hand through its bearing upon the crossbar *N*.

Adjusting a Pressure Gage

If the gage runs up too fast or too slow, or appears "lazy," proceed to adjust it accordingly. A diagrammatical representation of a pressure gage is shown by Fig. 3, in which the Bourdon tube is shown attached to the steam pipe and the ends of the tube are connected by means of long and short links to a lever which actuates a rack and which meshes with a pinion upon a shaft to which the gage pointer is attached. Thus any movement of the tube due to high or low pressure, is transmitted to the pointer. In case the pointer runs up too fast in the higher pressures and down too slow in the lower pressures, it may be necessary to shorten the long arm of the lever by means of its adjustment. There is also a similar adjustment to the short arm, and by making proper alterations of one or both of these, the gage hand may be made to run up evenly with that of the test gage.

Sometimes the tube may be distorted by being subjected to high-temperature steam. When this has taken place, it may be found difficult to adjust the gage so that the pointer will run up and down properly. When the inspector finds it impossible to make the pointer travel even with that on the test gage, he will proceed to set the hands of the gage under test so that it will be about correct at the figure denoting the pressure carried in the boiler to which the gage is attached. Thus the gage never gets much above or below the actual boiler pressure, but will be about right at the normal working pressure.

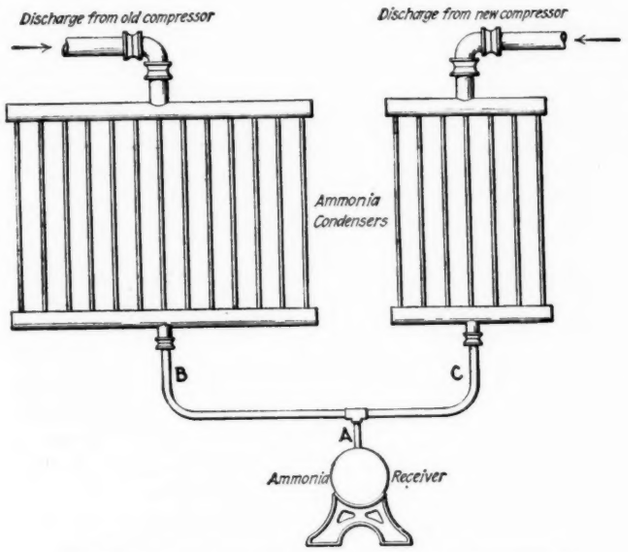
As soon as possible after completing an inspection, the inspector should write his report, using the data acquired during the inspection, and he should set forth in full a true account of each and every defect he has observed. The thickness of shell, heads, and the diameter of rivets should be obtained from the maker of the boiler or determined by the inspector by removing one or more rivets and carefully measuring of the plate thickness and the diameter of the rivets. He will then determine the bursting and the safe working pressure of the boiler thus inspected.

An Ice-Plant Problem

By Terry Mitchell

A puzzling problem came up in an ice plant where there were three ammonia compressors. Two of these were connected to a common discharge line, which ran to a large bank of condensers; the third compressor, installed a year after the other two, discharged into a separate set of condensers.

The addition of the third compressor to the plant was made in the spring, and everything worked satisfactorily throughout the summer. When cool weather came and the refrigerating load was light, the new compressor was shut down, but trouble at once developed. The two old machines started to heat up badly,



PIPE CONNECTIONS FROM THE CONDENSERS TO THE RECEIVER

the suction pressure dropped very low, and all the freezing-tank coils were pumped out dry.

The machinery was stopped and an investigation begun. As all the valves, the condenser water flow, etc., appeared to be adjusted properly, the compressors were put into service again. After repeated trials it was discovered that the system would work smoothly as long as the new compressor was run at the same time with one or both of the old machines. But if this compressor was operated alone, the coils would be pumped out just as they were when the two other machines were operated alone.

This was a puzzle. The difficulty was to get the ammonia into the expansion coils; but what relation this had to the order in which the compressors were worked was the question. It made no difference how much water was pumped over the condensers; furthermore, the head pressure never went up. A check showed the condenser and receiver valves to be wide open.

The owners of the plant finally wrote to the engineer who had erected the new compressor, asking him why it would not work alone and why it would not allow the others to be operated without it. Being an old hand at the game, the engineer figured that the ammonia was not going to the receiver from the condensers, which would allow the coils to be pumped dry under the conditions described. With this as a clue he discovered the secret.

The ammonia receiver was connected to the liquid headers of the condensers by two lines *B* and *C*. A tee was fitted to the riser above the receiver, as can be seen in the illustration. The liquid line *A* was so small that when only one bank of condensers was having gas pumped into it, the liquid leaving it would run down *B*, past the tee and up through *C* into the other set of stands. The receiver being warmer than the condensers, ammonia gas boiled off from the liquid contained in it, and by its pressure prevented the liquid above from draining into the riser. When both banks of condensers were under pressure from the compressors, the liquid ammonia was forced into the receiver from both *B* and *C*, the gas pressure from the receiver being overcome by that of the ammonia compressors above. Thus it was necessary to operate the new compressor at the same time with one or both of the old ones.

Of course this trouble was easily corrected by installing a larger liquid line and riser above the receiver. This saved the operating engineer the trouble of shutting off the liquid valves on the idle condensers, which would have accomplished the same result.

Corrosion and Erosion in Centrifugal Pumps

It is often noted in centrifugal-pump installations that after a period of operation the runner, shaft and inside of the casing become pitted and eroded. Some of this erosion is undoubtedly due to mechanical abrasion and may or may not be preventable according as the character of the material pumped may or may not be made free of suspended matter.

There are also the troubles due to electrolysis in salt-water pumps. This difficulty has been successfully overcome by the use of the all-bronze pump, in which the casing and runner are both bronze and the portion of the steel shaft that is under the pump is protected by a shrunk-on brass or bronze brushing or shaft sleeve on either side of the runner.

There is still another difficulty in the operation of centrifugal pumps, which likewise causes a species of pitting—a sort of rippling erosion on both casing and runner, caused by the action of entrained air in the liquid pumped. This difficulty can be greatly reduced by eliminating all possible chances of air becoming entrained in the liquid. First of all, the suction line should be tight, free from air pockets and sharp elbows or other fittings and all bends should be long-sweep. The pump itself should be kept tight and the glands properly packed and adjusted, with a small stream (¼-in. pipe) of water flowing in at the glands to act as a water seal and prevent the infiltration of air. Lastly, the pump should be properly primed before starting, so that no air remains within it to be churned with the liquid. The use of the aforementioned precautions will greatly facilitate the operation and lengthen the life of the average centrifugal pump.

When several boilers are connected to a common flue and one or more are taken out for cleaning, care should be taken to have the dampers closed tightly. In some cases it is well worth while to plaster around the damper if the boiler is to be idle for any length of time. In this way considerable reduction in draft can be avoided, or if induced draft is used, a decrease made in the amount of gas to be handled by the fans.

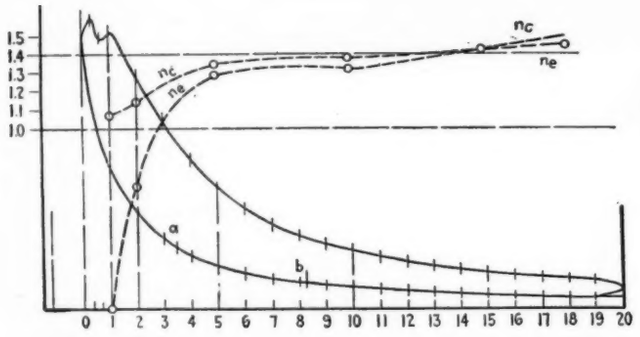


FIG. 1—INDICATOR DIAGRAM FROM SULZER DIESEL

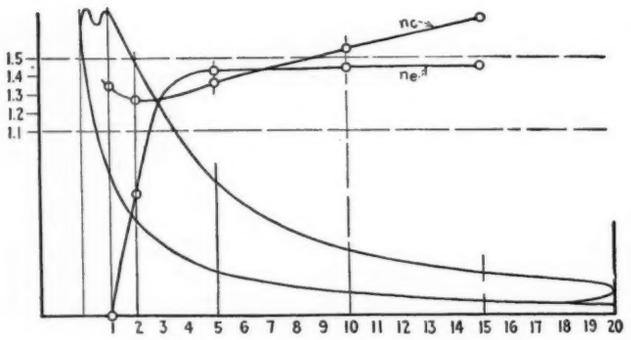


FIG. 2—DIAGRAM WHEN SULZER ENGINE WAS OVERLOADED

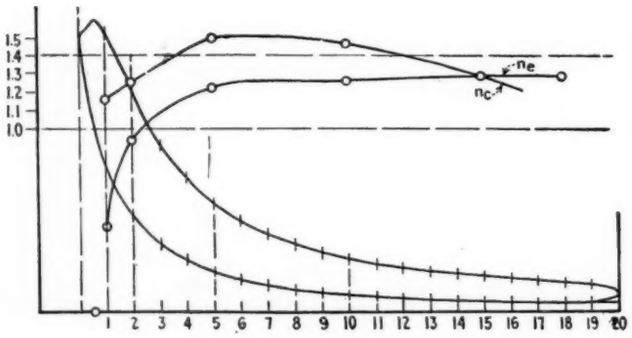


FIG. 3—HEAT ACTION IN M.A.N. DIESEL

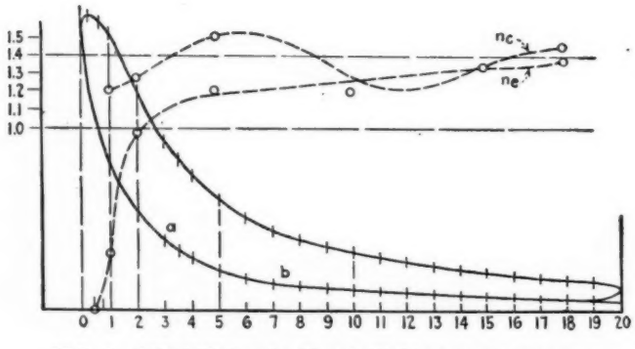


FIG. 4—PECULIAR DIAGRAM FROM M.A.N. ENGINE

Judging Engine Performance by the Indicator Diagram

BY P. H. SCHWEITZER

THE study of indicator diagrams from internal-combustion engines is not only fascinating but profitable work. As was pointed out in *Power*, April 10, by drawing tangents to the compression or expansion line of a diagram the rate of change in the slope of the curve may be found. By charting this rate of change, or the value of n for a number of points, the heat action in the cylinder is shown.

To illustrate the value of this system, which involves the use of a mirror for obtaining the tangent to a point, a number of diagrams will be investigated. In Fig. 1 is shown a diagram from a Sulzer four-stroke-cycle Diesel with a compression-volume ratio of 14. The cylinder bore was 11.1 in. and the stroke 16.5 in., while the speed was 226.5 r.p.m. The values of n along the compression line are indicated by the line marked n_c, while the line n_e is for the expansion stroke.

During compression a value of 1.41 for n indicates an adiabatic action, and a lower value is proof of heat loss to the cylinder walls or valve leakage, while higher values denote heat absorption by the cylinder contents. On the other hand, during expansion a low value of n denotes heat addition and a high value indicates heat loss.

The compression n line from points 15 to 5, in Fig. 1, has a nearly constant value of 1.4. This indicates little cooling by the cylinder jackets during compression; the droop from 5 to 1 is no doubt traceable to good cooling of the combustion chamber, or upper portion of the cylinder bore. The expansion line is very steep at the beginning, the peak or highest temperature occurring at 3, where the curve cuts the isothermal ($n = 1$). From this point to the end of the stroke, n increases slowly, which indicates a gradual addition of heat by after-burning. The 1.41 value is reached at about 70 per cent of the stroke; at this point the afterburning is practically at an end.

The engine, when overloaded 10 per cent, gave the diagram in Fig. 2. It will be noticed that the n line for expansion rises at a much more rapid rate than in Fig. 1 by reason of the increased fuel supply. Combustion, however, is not completed even at the end of the stroke, for the n line remains under the 1.41 value and increases slightly all along the stroke. The reason for the afterburning is traceable to the shortage of air. With normal loading the air to oil ratio is 31, while with 10 per cent overload the increase in the oil supply reduces the ratio to 25.4. Even though there was an excess of air on overload, evidently the oil spray did not mix with the entire air charge in the combustion chamber.

The increase in load also influenced the compression line. In Fig. 2 the n line for compression, n_c, starts higher than in Fig. 1, showing an absorption from the hot cylinder walls. The average of n_c is 1.39, indicating poor cooling of the jacket. One is safe in concluding

that the final compression temperature was abnormally high.

Indicator diagrams from M. A. N. Diesels appear in Figs. 3 and 4. The first was a 14.7 x 22.4-in. two-cylinder engine operating at 167.7 r.p.m.; the second was a double-cylinder unit, 11-in. bore by 17.3-in. stroke running at 192 r.p.m. Both show uncompleted burning, although the spray-valve action was excellent since the n_e curves start low and rise sharply, indicating quick ignition. The air to oil ratio was over 30 to 1 in both engines. Why combustion was not completed in a reasonable time is unknown. These diagrams show a peculiarity observed in M. A. N. engines by other investigators. The n_e line of each engine shows a considerable heat introduction in the middle of the stroke. To account for this is not easy; an explanation offered is that water or oil vapor condenses at this point, giving up its latent heat to the air charge.

A Nobel high-speed Diesel, 13-in. bore by 14.97-in. stroke, at 350 r.p.m. gave the diagram shown in Fig. 5. On account of flat portions on the curve only a part of the compression n line could be plotted; the portion plotted reveals a strong cooling action of the combustion chamber. The expansion n line indicates a quick ignition and an early end to the combustion period, burning ending before the point X.

A Fulton Diesel built in 1922 gave the diagram in Fig. 6. The compression n line is unusually high and does not drop below the adiabatic until the stroke is almost completed. This indicates a hot engine, which may be due to the late opening of the exhaust valve. This late opening caused the cylinder temperature to be higher during the exhaust stroke than would have been the case if early exhaust-valve opening had permitted most of the gases to pass out before the piston reversed its travel. The jacket-cooling effect was not up to standard, since the air charge continued to absorb heat from the hot walls during most of the stroke. The combustion-chamber cooling apparently was good, although the piston cooling might be responsible for the difference. The expansion n curve shows a quick ignition and a completed combustion at the point A. Strangely, the curve falls below the 1.41 value at B, indicating an addition of heat. This is probably traceable to burning of the lubricating oil on the cylinder walls.

It will be noticed that all the diagrams of air-injection Diesels have shown quick ignition. Solid-injection engines, on the other hand, usually have a slower ignition, but if built correctly have a good combustion.

In Fig. 7 is a diagram from a 20 x 34-in. De La Vergne solid-injection engine while carrying full load; Fig. 8 is from the same engine carrying a 10 per cent overload. The n lines for expansion in both diagrams start above the zero line, since the diagrams have sharp peaks as is usual with solid-injection engines. The further run of both n curves for expansion indicate fair and uniform combustion and only slight afterburning. It is safe to conclude that the designs of the combustion chamber and spray valves are good. With overload the combustion is, of course, slower. The compression n curve shows a not very satisfactory cooling in both cases.

The n curves of explosion motors show different characteristics. The heat introduction near dead center is very strong and gives to the expansion n curve an extremely steep rise. The $n = 1$ value (maximal temperature) is reached early in the stroke and the balance of the n curve is influenced mainly by the speed of the

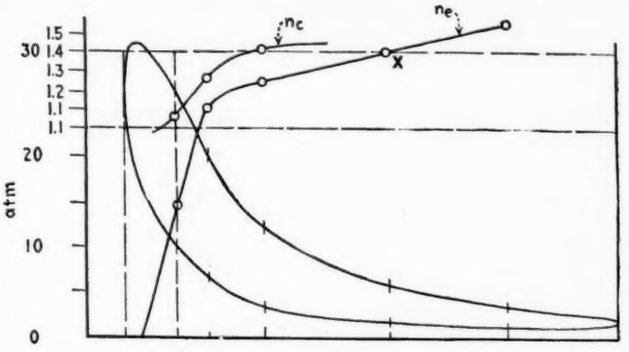


FIG. 5—NOBEL DIESEL GIVES A GOOD DIAGRAM

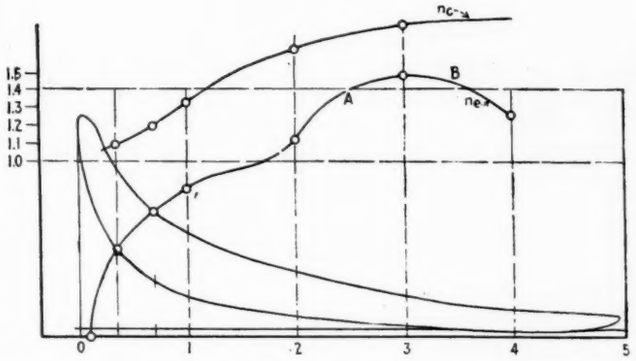


FIG. 6—DIAGRAM FROM FULTON DIESEL

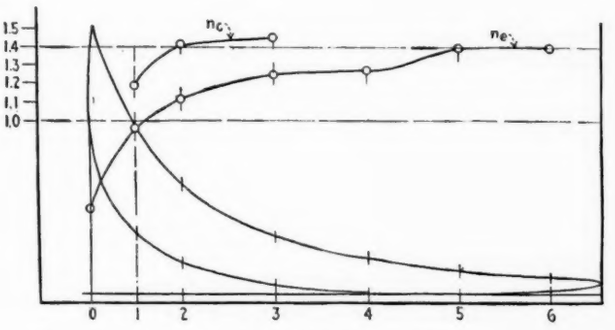


FIG. 7—DE LA VERGNE SOLID-INJECTION ENGINE DIAGRAM

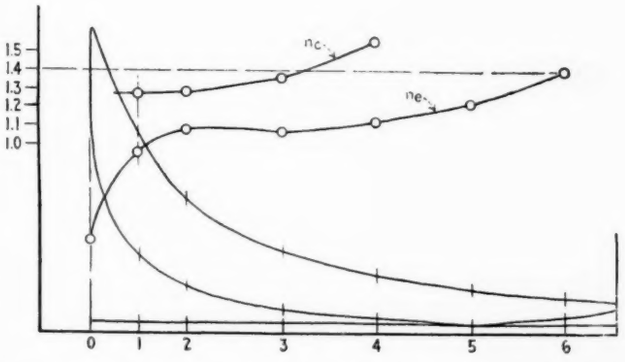


FIG. 8—SAME ENGINE AS WITH FIG. 7, BUT OVERLOADED

engine. As a rule, well-designed low-speed explosion engines show an early end to the combustion, while high-speed explosion engines have after-burning to a marked degree.

How the n curves can be of assistance in experimental work is shown by Figs. 9 to 12. A 12-hp. oil engine from the Gasmotorenfabrik Deutz was tested with three different spray valves and indicator diagrams taken. The spray valve of Fig. 9 had five 0.03-in. holes and a 23-deg. bore angle. The spray valve at Fig. 10 had eight 0.02-in. holes and a 23-deg. bore angle, and the spray valve at Fig. 11 had eight holes, 0.02-in. in diameter and a 43-deg. bore angle.

The n curves of the expansion strokes show at a glance that the spray valve of Fig. 9 is the best and that of Fig. 11 is the poorest. The difference between Figs. 9 and 11 is not considerable, both indicating a rapid burning and an early end to the combustion period. The increase in the spray angle to 43 deg. caused a pronounced prolongation of the combustion period. In Fig. 11 it is shown extended to the point X, the intersection with the $n = k$ value.

The cross-section of the combustion chamber, Fig. 12, explains the unfavorable effect of the increase in the spray angle. The 43-deg. angle allows the oil to strike the water-cooled surfaces, and as a consequence the combustion is poorer. The fuel consumptions prove the foregoing conclusions, being 0.51 lb. per b.hp. with Fig. 9 spray, 0.525 with Fig. 10 and 0.565 with Fig. 11 spray valve.

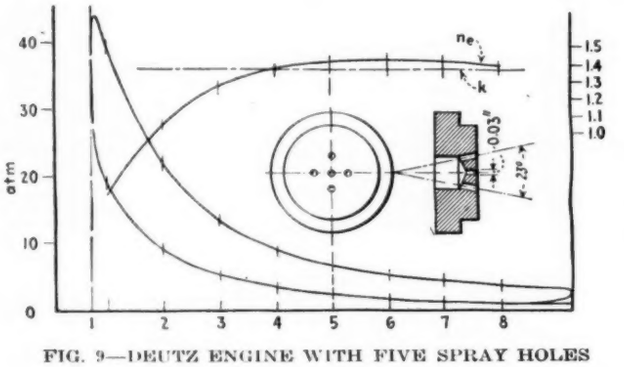


FIG. 9—DEUTZ ENGINE WITH FIVE SPRAY HOLES

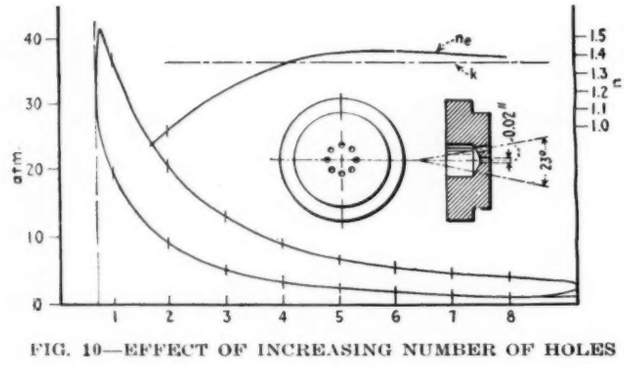


FIG. 10—EFFECT OF INCREASING NUMBER OF HOLES

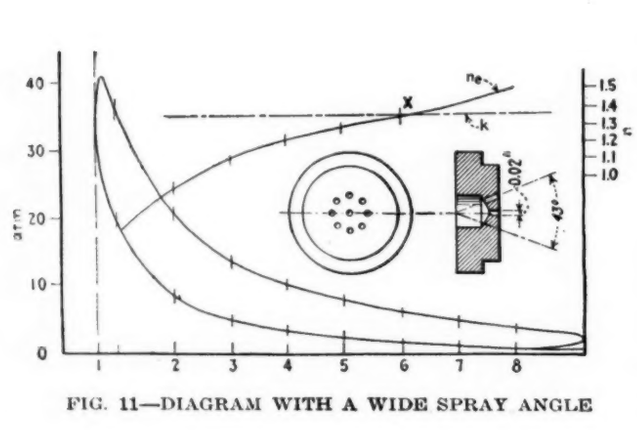


FIG. 11—DIAGRAM WITH A WIDE SPRAY ANGLE

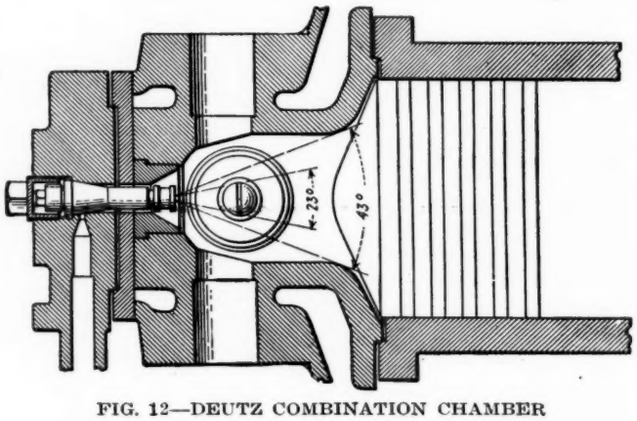


FIG. 12—DEUTZ COMBINATION CHAMBER

It will be noticed that the k line shown on these diagrams has not been drawn with a constant value, but is curved and somewhat below the 1.4 value. This is a more accurate way to represent the adiabatic exponent, considering the variability of the specific heats with the temperature. For gases resulting from the combustion of petroleum fuels the change of k with the temperature can be expressed approximately by the formula:

$$k = 1.40 - \frac{0.36t}{10.000}$$

By determining the temperatures in degrees Fahrenheit from the diagram and k for different points by this formula, the true k line can be plotted. The difference is, however, slight and for ordinary estimates the 1.4 value will suffice. Nevertheless, for exact researches and where high temperatures are present, the real k should be employed.

The quantity of circulating water to use in a surface condenser is an operating problem; in general it may be said that on a given condenser for any one load and inlet circulating water temperature there is a point above which an increase in quantity of circulating water will not result in any appreciable increase in vacuum; decreasing the quantity below this point results in a drop in vacuum, the rate of decrease of vacuum increasing faster than the rate of decrease of circulating water.

In practice a three-phase generator is one that has three armature windings so arranged that when one is generating a maximum voltage, the other two will be generating half voltage, and in opposition to the first, or as they are referred to, as being 120 deg. apart. The three windings are generally grouped so that there are only three wires coming out from the machine. The voltages between any two of the leads should be equal.

EDITORIALS

F. R. LOW, EDITOR

Byproduct Power

THE expression "byproduct power" in the title of the article on page 624 of this issue was used advisedly. True, the power obtainable from steam used for low-pressure process work is not strictly "free" even so far as heat consumption is concerned. Yet, leaving out of consideration for the moment additional investment and operating charges and considering fuel alone, its cost is extremely small. This statement applies to an installation where a steam engine or turbine is substituted for a reducing valve and where all the exhaust steam is used as heat for processes and buildings.

Under such conditions only about three pounds of steam per horsepower-hour can be charged against the power produced, this figure being practically independent of steam pressure, superheat, exhaust pressure or the steam rate of the prime mover. That is, the hourly steam demand on the boilers will be that with a reducing valve plus about three pounds per developed horsepower. This is but a small fraction of the steam consumption of the most efficient condensing plants. As a result the fuel cost for strictly "byproduct" power is almost negligible, and its total cost is chiefly a matter of capital charges and operating expenses other than fuel. In the matters of investment, labor, etc., power can, of course, be charged only with the increase over what would be necessary if a reducing valve were used.

Since the added steam demand is small, little if any additional investment is needed for boiler-house equipment, and the investment charge against power practically narrows down to interest and depreciation on the erected cost of a non-condensing generating unit and switchboard. There may or may not be a considerable increase in the cost of labor and attendance.

The conditions that tend to give the minimum capital and labor costs are: (1) Large pressure drop through the prime mover, (2) high load factor, and (3) large power requirements up to the maximum attainable from the given process load. The byproduct power plant has, however, such a heavy lead in the matter of fuel cost that only a very bad combination of low power demand, bad load factor and high back pressure can make the total cost of the power it generates greater than that of purchased power. Failure to take full advantage of byproduct power, particularly in those industries that use large quantities of process steam, is not only a great economic loss, but is also responsible for direct financial losses of millions of dollars yearly to the owners of such plants.

This statement does not mean that it *always* pays to generate power from process steam, nor that when such power is generated the entire exhaust should necessarily go to the process. It does mean, however, that the existence of a process load should invariably lead to a careful analysis of the situation to make sure that no source of cheap power is overlooked. The problem is not so simple that it can be handled in an offhand manner. It will often happen that enough power cannot be obtained from a simple engine exhausting to the process without producing at times an excess of exhaust steam. This raises the question of installing a low-pressure turbine or a bleeder turbine to secure complete expansion of the steam not used by the process.

The best combination depends not only on the average power and process loads, but also on the momentary variations in these loads throughout the day, week and year. Under certain circumstances serious consideration should be given to the steam accumulator, as now used in Europe to take care of the lag between the peaks of the power and process loads.

The point of all this is that the various possible combinations must be compared in the light of the conditions actually existing in the given plant. The investigation should be made by a trained engineer, one who understands steam from the ground up and knows how to figure costs. Such a man may easily save his employer thousands of dollars every year for the next decade by a single wise decision made now.

Abrupt Changes in Power-Plant Design

TRENDS in power-plant engineering practice are marked by distinct and almost abrupt changes. About twenty years ago reciprocating steam-engine driven units had reached their practicable size, 7,500 kilowatts, with a guaranteed water rate of thirteen pounds per indicated horsepower hour when operating on dry saturated steam at one hundred and fifty pounds initial pressure and expanding down to twenty-six inches vacuum.

Up to this time few if any turbines of capacities greater than five-hundred kilowatts had been designed. So long as capacities remained comparatively small and steam pressures and temperatures reasonably low, if there was any choice in prime movers it was probably in favor of the steam engine. As soon as sizes went above five-thousand kilowatts, the turbine began to have decided advantages. The practicable limitation placed on the steam-engine size caused reaching out for some means of overcoming this barrier, and in 1902 the epoch-making turbine of two thousand kilowatts rating was installed at Hartford, Conn. Not only was this machine a radical departure on account of its size, but also it had a single casting. About this time Sir Charles Parsons built a one-thousand-kilowatt machine, in which the expansion took place in two separate units on the same shaft. The success of the two-thousand-kilowatt single-cylinder turbine produced an abrupt change in the attitude toward this class of unit, which increased rapidly not only in numbers but in size. In 1903 the first five-thousand kilowatt vertical turbine was built, three years later the eight-thousand kilowatt unit came into existence, two years more saw the twelve-thousand-kilowatt machine, and by 1911 the size of these machines had reached twenty-thousand kilowatts in a single cylinder.

In other words, in about ten years the steam turbine had increased in size forty times, from five hundred to twenty thousand kilowatts. The growth in unit sizes since that time has resulted in the seventy-thousand-kilovolt-ampere triple-cylinder cross-compound machine.

Limitations placed on steam pressures, temperatures and vacuum by the steam engine were removed by the turbine, so that the first fifteen years of development produced remarkable changes in these values with a corresponding improvement in turbine water rates, decreasing from about twenty pounds per kilowatt-hour in 1903 to slightly over ten pounds in 1916 with steam at approximately three hundred pounds and a temperature of about seven hundred degrees. Difficulties experienced with these temperatures and pressures on valves and fittings became so serious as to deter operating men from going very much farther. Those who attended the A.S.M.E. annual convention in December, 1921, know that the consensus of opinion from operating engineers at that time was decidedly in favor of steam pressures around three hundred pounds and temperatures between six hundred and seven hundred degrees.

Reports from different sections of the country about large plants being designed for pulverized-coal burning, six hundred pounds steam pressures and temperatures of over seven hundred degrees, cannot fail to impress one that there is about to be another abrupt change in power-plant practice which will lead to decided improvements in efficiency. Individual units are being designed for one thousand pounds pressure and over for some of the plants, which are to be used to work out the engineering difficulties that may develop with such pressures. This wide adoption of higher pressures, temperatures, powdered fuel, preheaters, separately fired superheaters, stage bleeding for feed-water heating, etc., is not going to be accomplished without operating troubles. However, for the past few years it has been evident that if power-plant efficiency is to be improved very materially, some radical departure from present practice is necessary. The present move is a bold one, and many complications will undoubtedly develop that will require close co-operation among the operator, the designer and the manufacturer before satisfactory operating practice is obtained.

Reheating More Important As Steam Pressures Increase

THE reheating cycle represents a theoretical means of increasing steam turbine economy. By continuous reheating of the steam during expansion, the resultant pressure-volume curve may be changed from an adiabatic to an isothermal, representing a gain in thermal efficiency. Continuous and uniform reheating of this character is not now regarded as commercially practicable by any means so far proposed. The nearest approach to such a cycle is to withdraw the steam completely at some point in the expansion, and to reheat to nearly throttle temperature before returning to the lower-pressure stages for the remaining expansion. Additional heating points may be utilized if justified by the return on investment.

Although the reheating cycle has been applied in Europe, it has received much less attention in America than that of bleeding steam at several points during expansion, for the purpose of heating the condensate and therefore of increasing economy. Bleeding has been applied to the present-day steam conditions, supplanting to some extent the heating of condensate by the exhaust from steam-driven auxiliaries. The reheating cycle, however, has recently been specified for turbines in three large central stations.

The commercial application of reheating is due to the increase of steam pressures, inasmuch as raising the pressure increases the value of reheating to the plant economy. Bleeding alone becomes less advantageous as pressures approach near to the critical. Here saturated steam has no latent heat and a complete bleeding cycle would leave no work for the boiler or turbine.

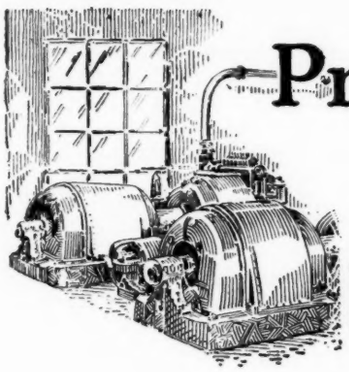
A turbine using steam at 250 pounds 700 degrees, with reheating at one point to throttle temperature, would gain theoretically in the neighborhood of one per cent, while a similar cycle at 550 pounds, 700-degree steam would show approximately twice as much gain. Besides the theoretical gain by reheating, due to approaching an isothermal expansion, there are a number of other factors, most of which tend to increase commercial economy as pressures are raised:

1. Substituting superheat in the lower stages increases mechanical efficiency due to decreased friction loss. This becomes more marked at higher pressures.
2. The added heat means less condensed moisture in the region of the exhaust. This in turn reduces friction losses over that in a machine without reheating.
3. As pressures are raised, the limit of temperature remaining constant, which is 750 degrees F. or thereabouts at the present time, the degree of superheat becomes continually less. The need of superheat derived from reheating therefore becomes increasingly important. In order to realize fully the advantages of superheat and restriction of condensation, several reheating points may eventually be commercially desirable.
4. With any reheating system the increase of steam pressure means greater pressure in the reheater. This naturally results in the smaller volumes and steam passages, so that where reheating for a turbine at 200 pounds at the throttle would mean comparatively expensive apparatus, that for 1,000 pounds at the throttle would at once appear feasible.
5. While higher pressures call for greater strength in reheater tubes, the increased heat conductivity of the denser steam makes for increased rate of flow and smaller tubes.

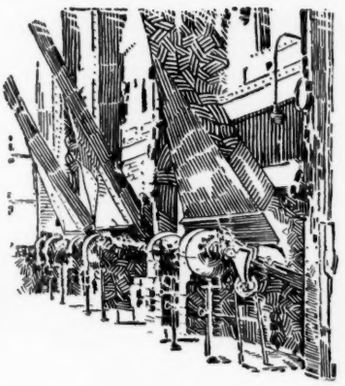
It should be remembered that at the present time we are in a way experimenting. Combinations of boiler, turbine and heater elements may be expected in the future, that will materially change the appearance of the turbine room.

A recent communication from the United Mine Workers to the Federal Coal Commission contains the pertinent question, "Why are the operators now charging $4 to $7.50 a ton for West Virginia coal at the mines, which they sold a year ago at $1.50 to $2.75 a ton, when there has been no increase in cost of production and no increase in the wages of the miners?" This is a question that the public would like to have answered as well as the miners.

In an editorial entitled "One Turbine, One Boiler" in the April 17 issue, reference is made to the production of 29.25 lb. of steam per square foot of heating surface. The decimal point was inadvertently misplaced; it should have been 2.925 or about 3 lb. of steam per square foot of heating surface.

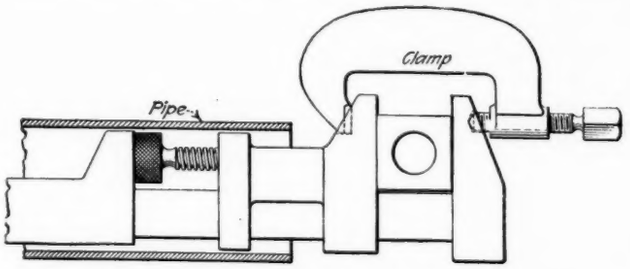


Practical Ideas *from* Practical Men



Saving Wrench from Damage

In dismantling a standpipe tower that had been constructed from steelwork and bolts that had been taken from other steelwork at random, it was found that as many as seven different sizes of nuts had been used on the bolts connecting the parts. These nuts were rusted and required such force to start them that two



CLAMP PREVENTS SPRINGING OF WRENCH

large monkey wrenches were sprung out of shape in attempting the work.

As other suitable wrenches to fit the various sizes were not at hand, a clamp, as illustrated, was applied to one of the monkey wrenches to stiffen the jaws and a leverage from a pipe, placed over the wrench handle and body as shown, gave the necessary power to continue the work. G. G. McVICKER.

North Bend, Neb.

Installation of Electric Brake Eliminated Elevator Trouble

On an old-type elevator machine equipped with a mechanical brake and driven by a two-phase motor, trouble was caused by the cars getting out of control of the operator. After the operator pulled the hand rope to the one position with a heavy load in the car, if for any reason the power failed to the motor, the car would start down and soon reach a high speed.

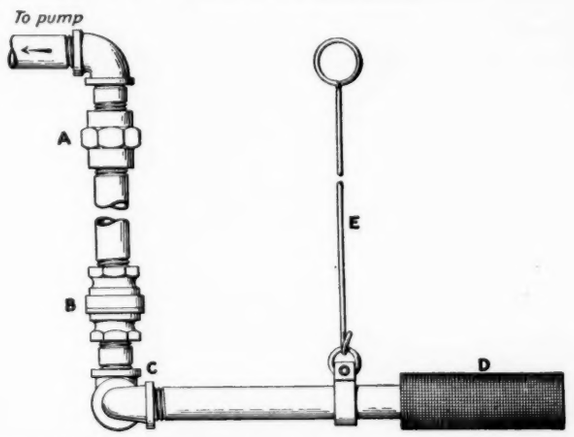
As a rule the man operating the car would get excited and jump off at the first landing he came to or else would pull the hand cable from one extreme to the other, which would change the machine limits and hand rope stop, in the position opposite from that they should be set, and the car would land heavily in the bottom of the hatch, allowing the cable to become loose on the drum with possibly a casting or two broken.

To prevent this trouble, it was decided to install an electric brake and a potential switch on the machine. This potential switch was connected so that the contact on the reversing switch had to be closed and the fuses O.K. before it would close and admit current to the brake and motor. Should anything occur to cut off the current while the machine was in operation, the electric brake would be applied and hold the car. A good double-thick endless belt was put on the motor, and substantial guards at the sides to prevent the belt coming off the pulley. In four years the machine has not cost anything for repairs and has been operated by anyone who wished to use the elevator. THOMAS SHEEHAN.

Springfield, Mass.

Eliminating Trouble from Water in Oil Tanks

Engineers who have had trouble with water getting into their fuel-oil storage tanks so that it comes above the oil-pump suction pipe will appreciate the value of the arrangement herein described. We have two tanks with a total capacity of 33,000 gal., and during the winter months considerable water gets into these tanks; so to be prepared for such trouble, we constructed the suction pipe as shown in the illustration.



HORIZONTAL SECTION OF PIPE IS RAISED OR LOWERED AS DESIRED

The union *A* was placed at the top of the tank so that the pipe can easily be taken out of the tank at any time. The foot valve *B* is at the lower end of the vertical pipe, and directly below this a swivel joint is made with the horizontal pipe by means of two elbows, as at *C*. A clamp is placed on the horizontal pipe with a ring in it so that the rod *E*, which is ¼ in. in diameter with a hook at one end and a loop at the other, can readily be connected to it. At the top of the tank are placed some

hooks for supporting the rod so that the suction pipe may be raised or lowered and not allowed to get into the water in the bottom of the tank. The water can be pumped out and the plant kept running. The screen *D* is made of ¼-in. mesh wire and about 12 in. long.

San Jose, Calif. ROY E. GRAVES.

Cutting Coils Out of Induction-Motor Winding

A short-circuit developed between two groups of coils in an induction-motor winding and destroyed eight coils. As there was no other motor available and it was imperative that this machine be kept in service, there was nothing to do but try cutting out the defective coils. As a total of twenty-four coils had to be cut out, it was felt that serious trouble might develop.

The winding had 180 coils connected for three-phase 10 poles 5-parallel star, as in the figure. The short-circuit occurred between groups 1 and 2. These groups are in series with groups 4 and 29 respectively and connected in parallel with eight other groups, each of twelve coils in series. If the four defective coils only were cut out of each group, 1 and 2, it would leave but eight coils in series in each of these circuits. To prevent cross-currents between parallel circuits, which could have happened if only the damaged coils were cut out, it was deemed advisable to cut out the complete

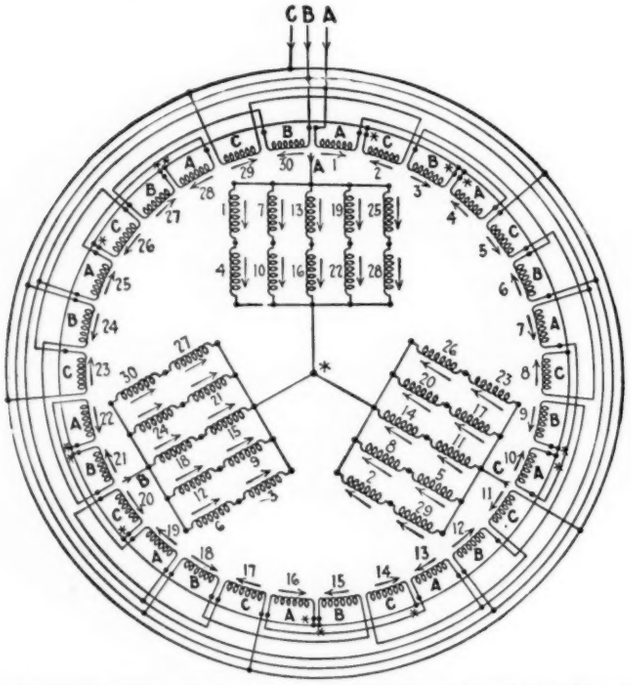


DIAGRAM FOR AN INDUCTION-MOTOR WINDING HAVING 180 COILS CONNECTED THREE-PHASE 5-PARALLEL STAR FOR 10 POLES

circuit, which included not only groups 1 and 2, but also 4 and 29, a total of twenty-four coils. Since the coils were not taped, they were pulled out of the slots after being cut in two.

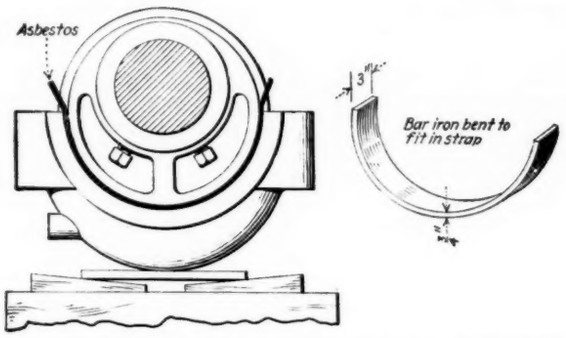
When the machine was re-assembled, it operated satisfactorily and ran this way for three months until another motor was obtained to take its place. The motor was taken out of service only for rewinding and not because it gave any trouble or lacked in power. When it is considered that four pole-phase groups of coils were cut out and all on one side of the stator, the satisfactory operation of the machine is more than might have been expected. ANTHONY J. MORRONI.

Denver, Colo.

Rebabbitting an Eccentric Strap

The eccentric strap on a single-eccentric Corliss engine needed rebabbitting. In order to melt out the old babbitt metal, the engineer forged four pieces of ¾x3-in. bar iron to the form shown in the illustration, heated them to almost a white heat and laid them, successively, in the halves of the strap.

Each half of the strap was babbitted while blocked up against the eccentric in the position shown. Strips



SHOW HOW STRAP WAS HELD IN PLACE, AND DETAIL OF MELTING STRIP

of sheet asbestos, making a total thickness of about $\frac{3}{16}$ in. on each side, were interposed between the flanges of the strap and the annular mortises at the edges of the eccentric's periphery. The joints formed by these strips were well plastered with fireclay. The eccentric and half-strap were then thoroughly heated with blow-torches, some powdered rosin was blown into the space between them, and the babbitt metal, heated almost to a dull red, was poured.

The metal ran perfectly into one-half of the strap, but a cavity about 4 in. long and 1½ in. wide remained in the other half. The engineer sprinkled some sal ammoniac and powdered rosin into the cavity, while the strap was still hot, and filled it with metal from the ladle. The fusion with the surrounding metal was perfect.

St. Louis, Mo. A. J. DIXON.

Points on Pressure Gages

A steam gage is supposed to indicate the pressure in the boiler to which it is attached. Some engineers persist in saying that a gage registers the pressure. Is this correct? Where does it register it? If a certain condition is registered, it is written in some form or other, so that it may be read at later periods. The ordinary steam gage does not do this, but indicates only the pressure, and when the pressure is changed, no record is left of what it had been at any time in the past.

Do steam gages always indicate correctly? If one of them indicates ten pounds, what does it really mean? Does it mean ten pounds in weight, the same as when we weigh iron or coal, or does it refer to some other system? If we make a box that is just one inch square,

and a trifle less than 28 in. high, place it in a vertical position and fill it with pure water, it will weigh one pound. Connect a correct gage to the bottom of it, and the gage will indicate one pound. This demonstrates that the steam gage indicates the weight of the water.

Suppose that we lengthen this tin box until it is approximately 3,733 ft. high and apply heat under the bottom of it, and maintain the flame until all the water is evaporated but none of it has escaped. The square box is full of steam, and it weighs just one pound, as it did when in the form of water.

By making a box 2 in. square and nearly 28 inches high and filling it with pure water, it will weigh 4 lb., but the steam gage connected at the bottom still indicates 1 lb. This shows that the steam gage indicates the pressure due to the height of a column of water, regardless of its diameter. Its indications refer to the pressure acting on each square inch of exposed surface at the height where the gage is connected.

Suppose that our box is strong enough to withstand more or less pressure. We put a slide in it at a height of 1,978 ft. The column of water is 1 in. square and 28 in. high. When it is evaporated, the gage indicates 15 lb. Renewing the experiment, we find that if the slide is located at a point approximately 817 ft. high and the pound of cold water is evaporated as before, the gage indicates 60 lb. The actual weight is 1 lb., but by confining the steam in a smaller space the pressure is greatly increased. The indications of the gage are based on the pound weight as before, still this shows that there is more than one way to affect its readings. By using 2 lb. of water in the same box and applying heat as before, the pressure would be much higher.

Take iron pipe of any convenient size and connect the lengths until it is 140 ft. long. Erect it in a vertical position and pour pure water in at the top. When it is 28 in. high, a gage connected at the bottom will indicate 1 lb. as before; at 11 ft. 8 in. it will show 5 lb.; at 23 ft. it indicates 10 lb.; and when the iron pipe is filled, the pointer stands at 60 pounds.

This demonstrates that if a gage is connected so that a column of water stands on it, an allowance must be made when observing the actual pressure on the boiler. For illustration, if there is a vertical pipe 11 ft. 8 in. high and the gage shows 100 lb., the actual pressure on the boiler is 95 lb. If the boiler is of the large vertical type and the gage is connected near the bottom of the shell, there will be 100 lb. actual pressure on this part of the boiler, but the steam at the top of the boiler is only 95 pounds.

I have in my plant a steam gage that never indicates less than 3½ lb. This does not prove that the pointer is set incorrectly. On the contrary it proves that the gage is correct, for the following reason: It is connected to a pipe near the ceiling, hence by calculating the weight as before mentioned, it shows that the weight of water resting on the gage is 3.5 lb. It indicates the pressure on a gravity heating system, hence when this gage shows 5 lb., there really is 1.5 lb. on the system.

Gages should always be connected so that cold water will stand between the spring or tube and the live steam. At the same time this fact introduces an element of danger, because this loop affords a place for sediment to collect until the pipe is entirely closed, thus showing either more or less pressure than actually exists in the boiler.

When a gage is not well protected in cold weather, the water in the loop will quickly freeze, and the expanding ice may cause the gage to show too much pressure. This will generally do no harm, but if the water in the pipe freezes when the pressure is really low and the fire is forced in an effort to raise the pressure, the result may be disastrous. If the safety valve operates properly no particular harm will result, but if it does not open freely at the proper time the fireman will naturally continue to force the fire and may possibly raise the pressure to a dangerous point.

There should always be a valve or a cock of some kind near the gage and another in the loop. By shutting the former and opening the latter, steam will blow through the pipe and remove all sediment. Do not open the valve near the gage until the pipe has cooled.

On some gages the pointer never vibrates, but only slowly moves to indicate changes in the steam pressure. This prevents undue wear on the moving parts, but gives the engineer no warning of a pipe that is nearly filled with sediment. In other cases the pointer may vibrate violently. When this occurs, the valve or cock in the connecting pipe should be nearly closed until the pointer barely moves, to show that it is not entirely shut off.

We sometimes find a steam gage connected to the top of a water column without a loop between them. The pipe is continued down until the end is submerged in the water. This may be all right under normal working conditions, but when the drip valve on the column is opened for the purpose of blowing sediment out of the connecting pipes, the lower end of the gage pipe will be exposed to the direct action of steam, thus heating the gage and possibly damaging the spring. As a general rule it is not good policy to connect a steam gage to a water column, because there should be valves in the connections, and when these are shut in order to make the column safe during the night (in a plant that is operated only during the day), the gage is shut off, hence it cannot show the pressure on the boiler.

Sometimes there are in an engine room two gages that are connected to the same line but their indications do not agree. It is not a difficult matter to correct this difference. Remove the pointer from the gage that shows the lower pressure and set it to agree with the other. Press the pointer gently down on the pivot and the job is done. The lower pressure is mentioned because it may not be possible to determine which is correct, and by following this suggestion, if there is an error it will be on the safe side.

A majority of steam gages are made with dials that are nearly white, with black figures to show the pressure, but a few have black dials with white figures. This change, like others which might be mentioned, is not an improvement, especially if the gage is in a dark room.

Gages are frequently located where only a ray of light strikes them from one side, thus throwing a greater part of the face in a shadow. They should be removed to a place where the light can be thrown squarely on the face. It is not a good idea to have a gas jet directly in front of a gage and close to it, as the fireman must look directly into the flame every time he notes the indication of the pointer. Many modern boilers have the gage placed several yards above the fireman's head. In such a case it should always be set at an angle that will make it convenient to read.

New Haven, Conn. W. H. WAKEMAN.

Comments from Readers

Squaring the Circle

The editorial in the March 13 issue, "Theory and Practice," very properly italicizes the words *"if the facts are correctly stated."* How many disputes hinge on an inexact statement of the problem is well illustrated by the editorial in the Feb. 20 issue, "Squaring the Circle." It is hardly just to mathematicians as such to assert, "The mathematician says the circle cannot be squared, meaning that there is no theoretically exact method of drawing a square of the same area as a given circle."

First, many mathematicians have repeatedly and clearly stated the case: "At the outset we must insist upon the difference between practical and theoretical constructions. For example, if we need a divided circle as a measuring instrument, we construct it simply on trial."

Second, proving π to be incommensurable and calculating its value to several hundred decimal places, is for theoretical, not practical, purposes. Practical solutions were 3.16 in King Tut's time, 3.1416 in the fifth century B. C.

Third, several exact graphical methods were also known several centuries B. C. Curves traced by simple mechanical devices practically solved the problem.

Fourth, the objection of Plato to the use of these so-called higher curves was that limiting the devices to two instruments, rulers and compasses, enhanced the "value of geometry as an intellectual exercise." The practical result of this restriction was the development of Euclidian geometry and extension of knowledge in pure mathematics.

Fifth, demonstration that a general solution is impossible using straight-edge and compasses alone is a modern achievement in pure mathematics for which no practical utility has ever been claimed.

Of course your conclusion is correct, although the blame has erroneously been placed upon the mathematician and "the engineer who, while gladly taking all the mathematician has to offer, will free himself from artificial restrictions, will rarely find it impossible to get the answer he is after." R. H. MERRILL.

Grand Rapids, Mich.

Should Steam for Heating and Process Be Charged to Power Plant Costs?

I was very much interested in the article of Mr. Maconnell in the Jan. 16 issue and that of H. D. Fisher in the March 13 issue, on charging steam to process, treating exhaust steam as a byproduct, and giving credit to the power plant. My views on this, and how I worked them out in my own plant, follow.

When I took charge of the plant thirteen years ago, not much thought was given to the cost of operation. After running for about one year and studying conditions for a general change of system, I found that 95 per cent of the process work that was being done with live steam could be done with exhaust. So I changed all heaters and glue line to exhaust steam. This made a saving of $1,100 a year for coal. The plant was small at that time, consisting of two water-tube boilers, one engine, one boiler-feed pump and one vacuum pump. We took out the vacuum as soon as a return-water-pump could be installed. In my opinion a vacuum pump has no place in a manufacturing plant.

At the present time the plant equipment includes three boilers with a total of 12,000 sq.ft. of heating surface, two engines, one steam-driven air compressor, and two boiler-feed pumps. All the exhaust steam from the main units and auxiliaries is used nine months out of the year.

We know what it costs to produce this exhaust steam, so a separate cost account is kept for each department. Some of the departments that take steam for heating only are figured on the cost per square foot of radiation. This same unit of cost applies to all departments for heating. The power is all motor-driven, and the current is metered in the engine room. This gives us a chance to charge each department its proportionate share of the power costs. Practically all the refuse that is used for fuel is made in two departments, and each of these is credited with its proportionate share, which brings their cost per horsepower lower than some of the others. So the power plant might be considered a factory by itself, selling its manufactured product (power) and making money on its exhaust, which is a byproduct well disposed of. W. H. YEOMANS.

Grand Rapids, Mich.

Diesel Engineers

I quite agree with J. H. Bender in his remarks in *Power*, April 10, on the need of competent oil-engine operators. It is surprising to find how little some, and I believe that I am safe in saying the majority, of the Diesel engineers know about the principles upon which this engine operates and the care demanded by the machines in their charge. It is still more distressing to observe how few are trying to familiarize themselves with these points of vital importance. One is led to believe that the great majority of engine failures should be attributed to the incompetency or carelessness of the engineer.

The most essential requirement in the Diesel engine field today is the Diesel engineer; not the kind of engineer who knows all about Diesel engines, because there are few such men, but the kind of engineers who studies his engine, knows when and how to adjust the bearings, how to obtain the highest efficiency from his engines, etc. This is the kind of engineer that is in demand today. The Diesel engine industry is in its infancy but is growing fast, and it should be a self-imposed duty for all connected with the business to keep posted on current developments, for the once perplexing problems are being threshed out rapidly.

It is remarkable how some engines stand up under

unsatisfactory working conditions. Recently, I conducted a crankshaft test on a 250-hp. Diesel. This engine was giving satisfactory service and no misalignment was evident in so far as operation or detection with the eye was concerned. But when the check was concluded, it disclosed the fact that the stub-shaft carrying the flywheel was 0.033 in. lower that the crankshaft. As the stub-shaft was rigidly coupled to the crankshaft, the latter suffered alternative bending stresses each revolution. The reason for this was attributed to the following: The engine foundation was well seasoned before the engine was moved on, being about ten months old. After the main foundation was put in, the construction work was temporarily suspended and the outboard bearing block was run when the work was resumed again. The misalignment was no doubt due to the settling of the outboard bearing block. Incidents of this kind prove that the machinery is not getting the attention that is due it, and, furthermore, they should induce the operator to check up on the condition of the engine, taking nothing for granted. The idea should be to find any existing trouble before it becomes serious and so avoid a shutdown.

Dallas, Tex. J. M. GREAT.

Motorizing Electric Generators

In reading the article entitled, "Motorizing a Three-Phase 600-Kva. Alternating-Current, Engine-Driven Generator," by Marshall L. Barker, appearing in the issue of April 3, I note that he asks whether a two-phase or a single-phase alternator would have acted the same under similar conditions.

If any alternator, whether polyphase or single-phase, is operating in parallel with other alternators, and the steam is shut off from the engine driving one of the alternators, this alternator will continue to run as a synchronous motor, taking power from the other alternators, in proportion to the motor losses and the mechanical load connected to the motor.

An alternator of the size of the one in question could not have been started from a standstill without additional switching equipment, such as is generally used for synchronous motors of that capacity. It would have to be equipped with squirrel-cage windings on the pole faces and connected to a starting compensator, so as to be started as an induction motor, which is the usual method of starting synchronous motors.

If a shunt-wound direct-current generator is operating in parallel with other machines, and the throttle on the engine driving it is closed, the generator will run as a shunt motor in the same direction in which it was running before the throttle was closed, and the speed can be regulated by manipulating the field rheostat. No reversal of the field leads is necessary, because the direction of the current in the shuntfield windings is the same, whether the machine is operating as a generator or a motor.

With a series-wound generator provisions should be made for changing the field connections, as the direction of the current in the series field is reversed, when the generator is run as a motor, and the tendency would be to stop the engine and start it running in the opposite direction. This could not be done without the risk of seriously damaging either the engine or generator, or both.

With a cumulative compound-wound generator the field strength is the sum of the series and shunt ampere-turns. If this type of generator is motorized and the series field connections remain unchanged it will be operating as a differential compound-wound motor. Therefore, in order to have the same field strength, it is necessary to change the series-field connections; but the shunt-field connections need not be changed.

Chicago, Ill. PETER G. DAHL.

Water-Tube Boilers at Sea

I read with interest the articles appearing in the Feb. 27 and March 27 issues entitled "Water-Tube Boilers at Sea."

Concerning the safety of the water-tube boiler as compared with the Scotch, it may be true enough that tube explosions in water-tube boilers may be more disastrous than tube explosions in Scotch marine boilers. The fact remains, however, that if a Scotch marine boiler should explode, the force of the explosion would be greater than that caused by the explosion of a water-tube boiler of equal capacity, on account of the smaller quantity of water contained in the latter.

The danger of a drum of a water-tube boiler exploding is comparatively small. In some types of Scotch marine boilers probably the most vulnerable part is the crown sheet, which requires the support of heavy crown girders to prevent its collapse and which is also the first part to become overheated in case of low water.

A water-tube boiler can be forced considerably above its rated capacity because it has much better water circulation. This also prevents, to a great extent, scale formation in the tubes, thus insuring better heat transmission and, consequently, better steaming qualities. With a Scotch marine boiler the water circulation is not so good as is generally conceded, and priming is frequently the result of trying to force it above rating.

It was remarked that additional heat from harder firing could only result in the production of more steam, no matter how much water a boiler contains or how much steel there is in it. But the quantity of steam produced depends on the quantity of heat absorbed by the water in the boiler, and this again depends largely on the circulation of the water in the boiler and the rapidity with which the steam is liberated. The production of additional heat in the furnace of a boiler with poor circulation, which is already working at its rated capacity, results not so much in additional production of steam as in adding to the quantity of heat passed up the stack.

The principal reason why the water-tube boiler is not already used in the majority of the merchant ships at this time is probably the fact that the marine engineer is conservative and in many cases prejudiced against anything comparatively new and untried. He cannot afford to take any chances with equipment that will not stand up under the severe conditions encountered at sea, as a breakdown at sea is far more serious than it would be in a stationary plant.

The fact that the use of the water-tube boiler at sea is on the increase and that it is now the standard in the Navy, are indications that show the superior merits of this type as compared with the Scotch marine. The increased use of water-tube boilers cannot be due to good advertising only, because no matter how well advertised a boiler is, it is a failure if it fails to stand up under the severe conditions encountered at sea, and the demand for such boilers would soon cease.

Chicago, Ill. PETER G. DAHL.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Requisites of Cylinder Lubrication

What method is considered the best adapted for supplying lubricating oil to a steam cylinder? W. S. J.

Any mechanical means that will thoroughly divide the oil up into small globules and distribute it throughout the entire body of the steam may be considered worth while. The efficiency of any method of lubricating the steam cylinder is ultimately determined by its thoroughness in this respect. The difference between direct feed, or partial atomization, and full atomization sometimes means 50 per cent of the oil bill, and a substantial difference in the coal consumption. Best lubrication will result from complete atomization and the use of the correct lubricating oil.

Preheating Air Used in Oil Engines

Why is not the air supply preheated by the exhaust for obtaining greater economy of oil engines?

M. H. J.

By preheating the air, its density is reduced and a larger cylinder volume is required in order to give enough oxygen to burn the stated amount of fuel. Ordinarily, after a short run, an oil-engine cylinder becomes warmed to such a degree that there is no difficulty in obtaining a final compression temperature sufficient to ignite even the heaviest of fuel oil. In very cold climates, where tar oil is being used, there might be an advantage in such an air heater, even though it incurs a loss of power. However, oil-engine manufacturers are experimenting in the use of preheated air, with the view of obtaining better economy from utilization of lower pressures in larger cylinders.

Required Size of Reducing Valves

We are heating a large building with three 4-in. steam lines branching from a 6-in. header. We carry 15 to 20 lb. pressure on the boiler. In the coldest weather we open the supply valves of the branches each about one turn. We wish to increase the pressure carried in the header to 60 lb. Would two 2 x 4-in. reducing valves give us plenty of steam for the three 4-in. branch lines, or would a 6-in. reducing valve be more efficient?

M. P. C.

Two 2 x 4-in. reducing valves should be sufficient for supplying the three 4-in. branch lines with more steam at 20 lb. pressure reduced from 60 lb. than three 4-in. globe or angle valves each opened about one turn for supplying the branches from the header when it contains steam at 20 lb. gage.

Undoubtedly one 6-in. reducing valve would be of sufficient capacity for supplying all the branch lines, but the use of a single valve probably would not be as efficient a means of regulation of the supply required by individual lines, as at all times all the lines would be supplied with steam at the same pressure and differentiation would need to be obtained by the stop valve on each line, as at present. The best service should be obtained by having each branch line supplied through a pressure-reducing valve as well as a stop valve.

Lap for Valves of Single-Eccentric Corliss Engine

With a single-eccentric Corliss engine in what position should the admission and exhaust valves be placed when the wristplate is in the central position? F. M.

It must be assumed that the eccentric rod has been adjusted in length so the rocker vibrates an equal amount each side of a plumb-line passing through the center of the rocker pin, and the reach rod for operating the wristplate from the rocker has been adjusted to such length that the central mark on the wristplate hub will be swung the same distance on each side of the central mark on the wristplate stud.

Then when the wristplate stands in the central position, the exhaust valve rods should be adjusted to such lengths that the exhaust valves will be just closed, and each steam valve rod should be adjusted to such length that its valve will have sufficient lap over the opening edge of the port for holding it closed until steam should be admitted from the same end of the cylinder. The amount of lap thus required for the steam valves will depend on the amount the eccentric is advanced more than 90 deg. ahead of the crank for the purpose of obtaining release of the steam before completion of an admission stroke, and also to obtain compression by closure of the exhaust valves before completion of an exhaust stroke.

To find the amount of lap for the steam valves, temporarily set the eccentric 90 deg., or a little less, ahead of the crank and turn the engine forward to about $\frac{7}{8}$ or other fraction of the stroke at which it is desired release should occur in the admission stroke and compression should begin in the exhaust stroke. Then advance the setting of the eccentric until the exhaust valve, in the end that should have the steam released to exhaust, is just opened and the exhaust valve, in the same end of the cylinder as the piston, just closed. Next, place the engine on a center and adjust the length of steam valve rod on the same end of the cylinder that contains the piston so that the valve will have $\frac{1}{32}$ in. or the desired amount of opening for lead at the beginning of a stroke from the same end, and turn the engine over to the other dead center to adjust the steam valve of that end in the same manner. The steam valves then will have the proper lap when the wristplate is in the central position.

Determining Weight of Blowoff Water

How can I figure the amount of water blown down, in pounds per minute, from a water-tube boiler carrying 200 lb. pressure with 2½-in blowdown opening that discharges into a 2½-in. blowdown line 175 ft. long having ten elbows? H. A. B.

The amount of water that would be blown down per minute would depend on the actual size of opening and combination of special coefficients of discharge of each valve, fitting and section of piping through which the discharge takes place. Hence a computation of the discharge based on pressures and given sizes would be of little value unless based on coefficients determined by actual test measurement of the flow under the working conditions. The best method of determining the rate of discharge for a given set of conditions would be to measure the amount of feed water required to replenish the amount of water blown off during a given time when the regular pressure is carried, and the blowoff or any other cocks or valves in the blowoff line or connections are open the regular amount for blowing down; also observing that blowing off takes place with the regular back pressure at the discharge end of the blowoff line.

For making measurement of the equivalent makeup water with all inlets and outlets closed and only enough fire to hold the regular running pressure, mark the water level with a cord tied around the gage glass, discharge the blowoff for an observed length of time—the longer the better—and again mark the gage glass at the reduced level. Then at a subsequent time, when all other inlets or outlets of the boiler are closed and the boiler is cold, determine the weight of water discharged in drawing down the boiler water from one of the marked gage-glass levels to the other. Note the temperature of the water and by making due allowance for the density at the regular running pressure, the weight that was blown down at the running pressure can be determined and this divided by the number of minutes required will give very closely the number of pounds blown down per minute.

Determining Heat Content of Steam

Please decide the following: "A" claims that with a given pressure and weight he can determine the number of B.t.u. per pound in a given quantity of steam. "B" claims this cannot be done unless the quality of the steam is known. P. P. P.

In order to determine the heat content, or B.t.u. contained, per pound of the steam above 32 deg. F. from tables of properties of steam, it is necessary to know, or have the means of determining, the fraction of dryness or degree of superheating, as may be the case. However, if the term "quantity" signifies volume, and this is given as well as the pressure and total weight, the data are sufficient for determining the quality.

If the weight per cubic foot is greater than the density of dry saturated steam of the same pressure as given in the steam tables, the steam is wet and the quality or fraction of dry steam present may be found as follows:

Let W = Weight per cubic foot of the given steam, pounds;

$\frac{1}{W}$ = Number of cubic feet per pound;

f = The fraction of volume that is dry steam;

$1 - f$ = The fraction of volume that is water.

Fig. 1 may represent a cubic foot of the given steam and Fig. 2 may represent the same total volume consisting of f cu.ft. of dry steam and $(1 - f)$ cu.ft. of water.

If v = volume of 1 pound of dry steam at the given pressure, obtained from steam tables, $\frac{1}{v}$ = density of dry steam of the given pressure, and D = density of the water at the temperature corresponding to the pressure, then in one pound of the mixture there would be $\left(\frac{1}{W} \times \frac{1}{v} \times f\right)$ lb. of dry steam and $\left(\frac{1}{W} \times D\right) \times (1-f)$ lb. of water, or

$$\frac{1}{Wv} f + \frac{D}{W}(1 - f) = 1, \text{ from which } f = \frac{1 - \frac{D}{W}}{\frac{1}{Wv} - \frac{D}{W}}$$

Therefore, the fraction of a pound of dry steam in a

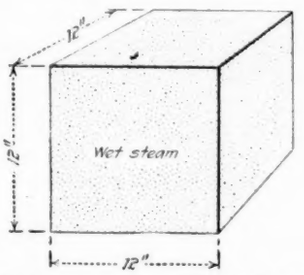


FIG. 1—ONE CUBIC FOOT OF WET STEAM

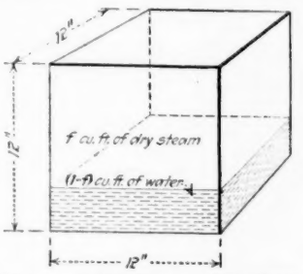


FIG. 2—WATER SEPARATED FROM THE WET STEAM

pound of the given steam, or its fraction of dryness, would be

$$\frac{1}{W}\left(\frac{1 - \frac{D}{W}}{\frac{1}{Wv} - \frac{D}{W}}\right)$$

If the density of the given steam is less than the density of dry saturated steam of the given pressure, the given steam would be superheated, and by reference to a table of properties of superheated steam, the B.t.u. per pound corresponding to the density and given pressure can be found directly, or by interpolating between the nearest densities.

Covering Heads of Drying Cans

Why are not the heads of drying cans or cylinders on paper machines covered to prevent losses of heat? L. S.

Heads of drying cans sometimes are covered with a non-conducting covering, but for many situations a non-conducting covering would take up valuable space and it would be difficult to apply and keep a covering in place. The loss by radiation usually is small in comparison with the heat usually transmitted by the cylinders, and the heat radiated from the heads is beneficial in keeping up the temperature of the paper-machine room for prevention of condensation of vapors on the walls and ceilings of the room.

Errata: Under "Heating Surface of Return-Tubular Boiler," page 534, April 3 issue, the statement, "The heating surface in the shell would be ⅔ of (72 × 3.1416) (18 × 12) = 48,858.1," is wrong, as the factor ⅔ was not used and the product should have been 32,572.1 sq.in., making the total heating surface 226,783.8 sq.in., or 1,574.8 sq.ft., in place of 1,687.9 sq.ft.

Easy Lessons in Engineering

"Rough-and-Ready" Calculation

Some engineers have what seems to their associates an almost uncanny way of looking at a bunch of data and making a close "guess" at the final computed result. In 30 seconds, perhaps, and without pencil or paper, they give an answer within 5 or 10 per cent of that which some other man obtains after half an hour of laborious computation. The process is at times so rapid that the results seem to come from intuition rather than from any mathematical operations.

Such rapid mental calculations are, as a rule, quite different from those performed by the "lightning calculators" of the vaudeville stage. The latter depend to a large extent upon a marvellous memory for figures. All their multiplications and divisions are exact to the last place. To repeat this stunt the engineer would have to be more or less of a genius or mathematical freak. But he gets his results in a different way. He simply dodges the hard work by dealing almost entirely with approximations. The ability to do this is a real asset to any engineer. It enables him to answer almost any question about his plant without delay, and also saves a lot of his time that would be taken up with exact calculations. The rough figures often tell him all he needs to know. If they do not, little time has been consumed and he may proceed to make an exact calculation. In that case the preliminary mental result serves as a rough check.

The processes involved in most practical computations are limited to addition, subtraction, multiplication and division. The chief tricks in rapid approximate mental arithmetic are, first, to be bold about making slight changes in the data and results to make these operations simple, and second, to cancel out a lot of the errors by taking some figures a little high and some a little low.

The best way to get the idea is to work through a few practical problems. First let us assume that we are looking at a cylindrical water tank and want to figure its capacity in gallons within about 10 per cent. By eye we estimate that the tank is 6 feet high and 4 feet in diameter. The volume in cubic feet will be the cross-sectional area in square feet times the height in feet. If the section were a square, its area would be $4 \times 4 = 16$ sq.ft. A circle inscribed in a square has about three quarters (0.7854) the area of the square. So call the area of the circle $\frac{3}{4} \times 16 = 12$ sq.ft. Multiplying this by the height of 6 ft. gives 72 cu.ft. Now there are $7\frac{1}{2}$ gal. in a cubic foot, so the capacity in gallons will be $7\frac{1}{2} \times 72$. This is the same as $\frac{3}{4} \times 720$. One quarter of 720 is 180, so three quarters will be 540 gallons. By exact arithmetic the answer would have been 566 gal.

As the next problem consider a case where it is desired to make a rough estimate of the amount of power required to operate a motor-driven feed pump supplying a 3,000-sq.ft. boiler when operating at 250 per cent of rating with a steam pressure of 200 lb. At normal rating the boiler evaporates about 3 lb. of water per hour per square foot of heating surface or $3 \times 3{,}000 = 9{,}000$ lb. per hour altogether. This amounts to $9{,}000 \div 60 = 150$ lb. per min. At 250 per cent of rating the total water fed per minute would be $2.5 \times 150 = 400$ lb. approximately. This must be pumped against a boiler pressure of 200 lb. per sq.in. Each pound per square inch is equivalent to 2.3 ft. of head, so the total head (neglecting friction) is $200 \times 2.3 = 460$ ft. To allow for friction and get a round number, call this 500 ft. The work done per minute in pumping 400 lb. of water against a head of 500 ft. would be $400 \times 500 = 200{,}000$ ft.-lb. This is $200{,}000 \div 33{,}000 = 6$ hp. (approximately), or $\frac{3}{4} \times 6 = 4.5$ kw. This would be the power consumption if the combined efficiency of the pump and motor were 100 per cent. If the actual efficiency is taken as 50 per cent, the power consumption would be $4.5 \times 2 = 9$ kw.

Another typical example would be found in estimating with the eye the weight of coal in an outdoor storage pile. Let us say that the pile is rectangular and appears to be about 120 ft. by 30 ft. measured along the outer edge. The maximum depth of the coal is about 15 ft., but if a wall were built around the pile and the coal leveled off, the depth would apparently fall to about 11 ft. We then would have a rectangular body of coal 30 ft. by 120 ft. by 11 ft. high. The product of 30 by 120 is 3,600 sq.ft. This, when multiplied by 11, would give about 40,000 cu.ft. Allowing 40 cu.ft. per ton (2,000 lb.) the total weight of coal in the pile would be $40{,}000 \div 40 = 1{,}000$ tons.

Hundreds of other practical examples could be found, but the foregoing serve to illustrate the method. The important thing to note is that the ordinary arithmetical processes of multiplication and division are used only where the numbers are (or can be made by slight changes) such as to make these operations extremely simple. Otherwise the products and quotients are obtained by considering the general size of the quantities rather than the exact figures. For example 0.9×11 is read at once as 10 and 0.85×0.9 as 0.75. The product of 110 by 9 would be read without hesitation as 1,000 and that of 9.5×8.5 as 80. The trick in the latter case is based on the fact that when two numbers of about the same size are multiplied the result is practically the same as if their average had been squared. So 9.7×10.3 would be read at once as 100, and 97.0×10.3 as 1,000.

Of course all the ordinary short cuts of straight arithmetic will be used where convenient. The most important of these are based on the use of reciprocals; for example, dividing by 0.2 instead of multiplying by 5, multiplying by 0.04 instead of dividing by 25 etc.

How Steam Production Costs Were Reduced

By A. R. MUMFORD
Assistant Fuel Engineer, Bureau of Mines

DURING the course of an investigation conducted by the fuel section of the United States Bureau of Mines,[1] on a hand-fired return-tubular boiler plant, it was found that the average cost of fuel to produce 1,000 lb. of steam was $0.5287. Tests conducted after some simple changes had been made in the furnaces, and in the control of the boilers, showed the previous high cost of fuel per 1,000 lb. of steam could be reduced to $0.3540, or the equivalent of over 30 per cent saving in fuel cost.

Original Setting and Modifications

The boilers were the ordinary return-tubular type 18 ft. long and 56 in. in diameter, set 27 in. above grates, 6 ft. deep and 5 ft. wide. The bridge wall rose to within 5 in. of the shell. The space behind the bridge wall had been filled in so that the floor of this space was only 20 in. below the shell. This form of setting is believed to be common and results in smoky and incomplete combustion when bituminous coal is used for fuel.

The combustion space in the original installation was small, and the gases were exposed to the cooling action of the boiler during their passage through the setting and, what is perhaps more important, were not subjected to any thorough mixing action. These conditions made it impossible to burn bituminous coal without producing more smoke than was permitted under the local regulations. For this reason pea-size anthracite was burned during the greater part of the day, and the plant was able to burn bituminous coal only at night when the demand for steam was somewhat less than during the day and when the smoke could not be seen.

The principal difficulties presented by the original setting were the small volume of the combustion chamber, which shortened the time allowed for the combustion of the gases; and the absence of any mixing device in the path of the gases which would have caused mixing of the combustible gases and air by changing the direction of flow of the gas stream and by changing its velocity. On account of mechanical difficulties involving excessive cost it was not feasible to alter the relative position of the grates. The combustion chamber beyond the bridge wall, however, had been built up from a concrete floor with filling and a layer of loosely laid brick, and by removing this filling the distance of the floor from the shell of the boiler was increased from 20 to 30 in. This increase in combustion-chamber volume permitted the gases to move at a slower speed for a given rate of combustion and excess of air, and therefore allowed them more time to burn completely.

The second obstacle was easily overcome by the installation of two semi-obstructing arches, one over the bridge wall and one in the combustion chamber. The vertical distance between the shell of the boiler and the top of the bridge wall was only 5 in. in the original installation, and this distance had to be increased to 10 in. before an arch could be placed over the bridge wall. This arch over the bridge wall closed off the former opening around the shell of the boiler and reduced the area available for gas passage from 5.6 sq.ft. to 1.7 sq.ft. The arch was extended for three feet from the front edge of the bridge wall in the direction of gas flow, to provide hot firebrick surface for the ignition of any combustible gas-air mixture not previously ignited. The reduction in area caused a temporary increase in velocity, which resulted in a turbulent flow, so that mixing was greatly assisted. The increase in velocity and the mixing action were accomplished at the expense of the available draft, and this is the determining factor that governs the extent to which such obstructions may be employed. Just beyond the bridge wall the area available for gas passage is 12 sq.ft., an increase of 10.3 sq.ft. over that available above the bridge wall. This increase in area considerably reduces the velocity of the mixture of gases which have come through the restricted area and so gives them a longer time to burn. The deflection arch in the combustion chamber was of single-span construction, extending from the floor to the boiler and leaving only a semicircular opening 4.15 sq.ft. in area next to the floor of the combustion chamber. This deflection arch caused the gas stream to turn toward the floor of the combustion chamber, and further assisted in mixing by causing a second contraction, increase in velocity, and expansion of the gas stream. These changes in furnace arrangement in connection with the introduction of an improved method of firing permitted the substitution of bituminous coal for anthracite at a reduction of approximately $3 per ton in delivered price.

[1]Advance copies of the complete report are being issued in mimeographed form by the Bureau of Mines under Serial No. 2455.

Original and Modified Method of Control

Before the furnaces and method of firing were modified, the operation of the boilers was left entirely to the firemen, as long as steam pressure was maintained above 100 lb. and below the blowing off point of approximately 110 lb. This resulted in irregular firing and increased fuel losses because the firemen added fuel or worked the fires only when the steam pressure was decreasing. The dampers on all the boilers under fire were always wide open, and if the steam pressure rose toward the blowoff point the firemen reduced the rate of combustion by closing the ashpit doors, and if the steam pressure continued to rise the rate of combustion was further reduced by opening the firedoors. Closing the ashpit doors to reduce the rate of combustion has long been recognized as poor practice and results in overheated grate bars, increased clinker formation and increased flue-gas losses. Opening the firedoors to reduce further the rate of combustion, not only results in the same evils that result from the closing of the ashpit doors, but in addition cools the boiler unequally and puts a local stress on the boiler which, especially with fire-tube boilers, increases the wear and repairs necessary on boiler and brickwork.

TABLE I—TIME SPENT BY FIREMAN IN VARIOUS OPERATIONS ON TEST BOILER

Test No.	Rate of Working Boiler, Per Cent	Time Spent on Firing, Min.	Time Spent on Cleaning, Min.	Time Spent on Leveling, Min	Time Spent on Barring, Min.	Total Time Spent During 12-Hr. Test, Min.	Time Spent per 1,000 Lb. of Steam Produced, Min.	Kind of Fuel
1	71	23.34	35.92	0	0	59.26	2.38	Anthracite
2	79	33.08	42.25	0	0	75.33	2.75	Anthracite
3	63	24.00	40.75	0	0	64.75	2.94	Anthracite
4	107	31.75	20.58	0	17.75	70.08	1.88	Bituminous
5	81	26.08	16.67	0	15.67	58.42	2.08	Bituminous
8	125	25.50	12.67	24.51	17.75	80.43	1.87	Bituminous
9	99	22.00	6.20	27.43	12.68	68.31	1.97	Bituminous
10	85	18.05	6.33	28.23 3.50*	1.93	58.04	1.97	Bituminous

*Hooking

In general, with ashpit door control practically the same draft at the breeching is available at all rates of combustion, but that part of the available draft utilized for actual combustion decreases with the rate of working the boiler. The excess of draft over that utilized for combustion draws air into the furnace and setting above the grates, thus increasing the excess of air and dry-gas losses as shown. With damper control, as substituted for the former method, the available draft is reduced by shutting the damper so that the draft available to the boiler is enough for the desired rate of combustion only, and no excess exists to increase the stack losses.

Original and Modified Method of Firing

Perhaps the best criterion to judge the practicability of a firing method, from the viewpoint of the fireman, is the amount of work he must do to produce a given amount of steam. If a new method requires more actual work on the part of a fireman, it is likely that it will be opposed, but if the fireman can be convinced that the new method requires no more work, and perhaps less work, it will be more readily

acceptable. In order to determine whether a fireman had to perform more actual work per 1,000 lb. of steam produced when he fired according to an improved method than when he fired without any attempt at regularity and without care, a record was kept on each test of the time spent on the various operations for each of the tests made.

The average work in minutes required of a fireman per 1,000 lb. of steam produced, as shown in Table I with anthracite is 2.69 min.; with bituminous coal, under former plant operation, 1.98 min.; and with bituminous coal, with the new firing method, 1.94 minutes.

To produce steam with anthracite requires more work than with bituminous coal, because the former contains more ash and has a lower heating value per pound than bituminous coal. The higher ash content of anthracite necessitates more frequent cleaning, and on account of the lower heating value a larger quantity must be fired to produce 1,000 lb. of steam.

Supervision Necessary at First

The new method of firing requires approximately the same actual work per 1,000 lb. of steam produced as did the former method with bituminous coal as a fuel. However, the new method also requires supervision until the firemen become accustomed to firing small amounts regularly, and to keeping their fires in good condition at all times. This supervision is the price to be paid for more complete combustion without objectionable smoke, and is equivalent to a saving of $0.0685, or 16 per cent in the cost of fuel per 1,000 lb. of steam. The time spent on leveling the fires is at least as much as that spent on firing, because this work is essential to good efficiency. It is the leveling of a fire which insures even combustion, for in this operation holes in the fire bed are covered and the coke bed is loosened so that combustion takes place more evenly. On Test 10 the fires were barred only after cleaning, when the fuel bed consisted almost entirely of freshly fired green fuel. The observations of the smoke prduced showed that barring a fire generally produced objectionable smoke, whereas leveling a fire from the top with a rake did not produce objectionable smoke. Even with a rake, however, smoke can be produced if the fireman is allowed to force the rake too deeply into the fuel bed. A safe method of operation with regard to smoke abatement is to use the rake for breaking and leveling the top of the fire without disturbing that portion resting on the grates. The grates themselves should be kept free from ash obstruction by running a flat hook over them at intervals of four hours. This hooking of the fires does not disturb the fuel bed to any great extent, but does keep the air passages in the grate bars open.

The improved firing method utilized the alternate system of firing. Thus only one-half of the grate surface is charged with green fuel at any one time, and the remaining half is left covered with a bed of freely burning incandescent coke from the preceding firing. In this way the fluctuation in furnace temperature is reduced and a temperature high enough to ignite the mixture of combustible gases and air, in the furnace, is maintained. The procedure followed was to charge with fuel that portion of the fire reached through one of the firedoors and to break and level the other half as part of the same operation.

Efficiencies and Costs Before and After Modifications

In order to determine the performance of the plant both before and after the modifications in the setting and control were introduced, a series of tests at different rates of evaporation per hour were made. Six tests, three with anthracite and three with bituminous coal, were made under the original conditions. After the conditions had been modified, three more tests were run with bituminous coal, to determine the actual improvement in efficiency.

Table II presents the heat balances of the whole series of tests. Tests 1, 2 and 3 represent plant operation with anthracite; tests 4, 5 and 6 represent plant operation with bituminous coal; and tests, 8, 9 and 10 represent modified operation with bituminous coal.

The principal features of the results obtained with anthracite are shown by the variation in efficiency, dry-gas loss, and ashpit refuse loss, with rating. The efficiency and dry-gas losses decrease as the rating increases, while the loss in the ashpit refuse tends to increase with the rating. The large ashpit losses are due to the high ash content in the original coal, which necessitated frequent cleaning of fires. It was fund that steam could not be supplied in sufficient quantities if the fires were permitted to burn more than four hours without cleaning, so that the high ashpit loss was part of the cost chargeable to smoke abatement under the original operating conditions. The decrease in dry-gas losses with increase in rating further discredits control of boilers by ashpit doors instead of by dampers, for the decreasing loss indicates that the available draft was more completely utilized for combustion as the rate of burning coal increased.

Under the modified operating conditions with bituminous coal the efficiency increases with a decrease in rating. The increase in efficiency is accompanied by a decrease in dry-gas losses and a decrease in loss due to carbon monoxide in the flue gases. The decrease in dry-gas losses with decrease in rating, just the reverse of the trend of the dry-gas losses under the original conditions, is brought about by the decrease in pressure difference between the inside and the outside of the setting as the damper is closed. This decrease in pressure difference decreases the influx of cold air through leaks in the setting, and consequently results in less dilution and cooling of the products of combustion, and therefore less waste of heat.

TABLE II—PERFORMANCE BEFORE AND AFTER MODIFICATIONS

	Before Modification						After Modification		
Number of trial...	1	2	3	4	5	6	8	9	10
Kind of coal.....	Anthracite			Bituminous			Bituminous		
Per cent of builder's rating.....	71	79	63	107	81	56	125	99	85
Heat Balance per Lb. Coal—As Fired:									
Heat absorbed by water, per cent..	57.9	55.7	58.9	66.0	61.0	59.0	66.5	65.7	69.0
Heat carried away by dry gases, per cent.....	18.9	18.4	20.1	22.1	24.0	27.7	19.0	18.5	17.4
Heat carried away by CO in dry gases, per cent...	0.0	0.0	0.0	2.8	1.0	1.3	1.4	0.7	0.7
Heat carried away by steam in flue gases, per cent...	2.3	2.3	2.3	3.7	3.6	3.5	3.5	3.5	3.5
Heat lost in ashpit refuse, per cent..	14.4	16.2	14.7	2.4	4.8	2.6	3.1	5.3	4.1
Heat unaccounted for, per cent.....	6.5	7.4	4.0	3.0	5.6	5.9	6.5	6.3	5.3
Total.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Evaporation per lb. coal, lb	6.61	6.36	6.73	8.70	8.05	7.78	8.82	8.71	9.15
Coal per 1,000 lb. steam, lb.	151.3	157.2	148.6	114.9	124.2	128.5	113.4	114.8	109.3
Cost of coal per 1,000 lb. steam,	$0.6943	0.7215	0.6820	0.3775	0.4081	0.4222	0.3726	0.3772	0.3591

Boilers Operated at Low Rating

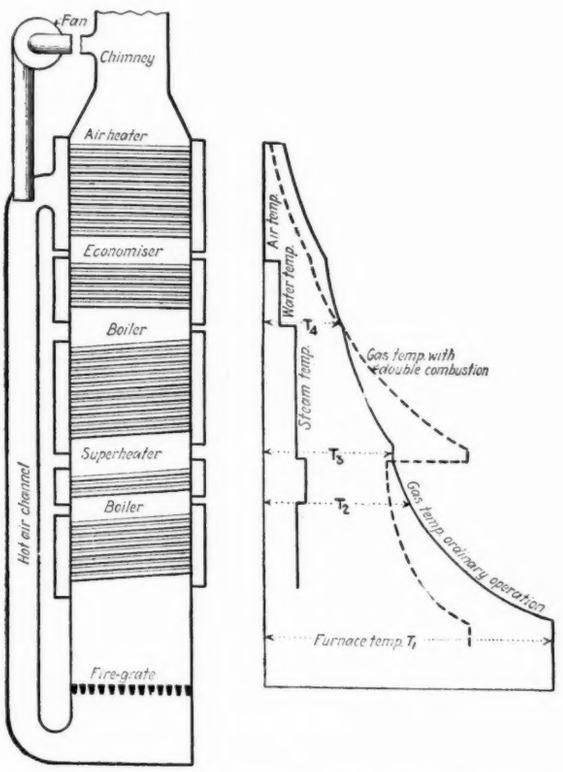
The fact that the efficiency increases with a decrease in rating under the modified operating conditions is an especially desirable condition because of the low average rate of working the boilers in the plant under consideration. The average rate of working the boilers was estimated to be 75 per cent of builder's nominal rating. Thus the gain in efficiency due to modifying the conditions was 13.2 per cent over the original conditions with anthracite, and approximately 9 per cent over the original conditions with bituminous coal. Thus from each 176 heat units in the anthracite, 100 heat units were given to the steam; and from each 176 heat units in the bituminous coal, 104 heat units were given to the steam before the modifications, and 123 heat units were given to the steam after the modifications.

The cost of coal per 1,000 lb. of steam under the original operating conditions at the average rate of boiler working was $0.7050 with anthracite and $0.4225 with bituminous coal. After modifying the conditions, the cost of bituminous coal per 1,000 lb. of steam was $0.3540. These figures were obtained from the costs of coal obtained from the delivery records for the eleven-month period from July 1, 1921, to June 1, 1922. During that period 2,653 long tons of bituminous coal were delivered at a total cost of $19,535.16, or $7.36 per ton, and 1.957 long tons of pea size anthracite at a total cost of $20,121.31, or $10.28 per ton. These figures were used because present prices are not stabilized.

High Boiler Efficiency With Low Furnace Temperatures

In his latest yearly memorandum, C. E. Stromeyer, Chief Engineer of the Manchester (England) Steam Users Association, made some comments on the possible use of double combustion to permit of high combustion efficiency with moderate furnace temperatures. An abstract of his remarks follows.

At the left of the accompanying illustration is shown diagrammatically a water-tube boiler with superheater, economizer and air heater. For the moment no attention need be paid to the fan shown at the upper left-hand corner. Without this fan the air drawn along by the induced chimney draft enters the air heater, passes down through the hot-air channel at the left, up through the grate and fire and then in succession through the first pass of the boiler, the superheater, the remainder of the boiler, the economizer, the



DOUBLE COMBUSTION WOULD GIVE HIGH EFFICIENCY WITHOUT EXCESSIVE TEMPERATURES

air heater and the chimney. At the right are shown (in solid lines) the curves for temperatures in the various sections of the apparatus. The gases, entering the boiler at the high temperature T_1, leave it at a considerably lower temperature T_2, and experience a slight further reduction to T_3 in going through the superheater. Finally, in passing through the remainder of the boiler, the hot gases drop to T_4. Throughout the boiler proper the steam temperature is practically constant except for the slight increase through the superheater.

If the boiler were further extended, additional heat transfer would be very slow on account of the small temperature difference, but the economizer section with its lower temperature produces another appreciable drop in gas temperature. This drop continues in the air heater.

With perfect combustion and a very small amount of excess air the furnace temperature T_1 might be 3,000 deg. F. or more, but at T_2 the gases would be cooled down perhaps to 1,000 deg. and could be safely used for heating the superheater.

In view of the injury done to boiler parts and to brickwork if the furnace temperature is as high as it must be with perfect combustion and a minimum of excess air, the suggestion was made some years ago to resort to double combustion. The fuel in the furnace would be burned not to CO_2 but to CO. The resulting temperature could not then exceed about 2,500 deg., and the temperature curve in the boiler would be as indicated by the dotted line. Having cooled the gases to, say, 600 or 800 deg. at the point of exit from the superheater, additional air would be mixed with the CO and perfect combustion would then result, but again the temperatrue would probably not exceed 2,500 deg. The heating surfaces would have to be proportioned both to the relative weight of the two gases and to the respective decreases of temperature. Undoubtedly, this arrangement would present difficulties when using customary types of boilers, but if entirely new types are to be evolved, the possibility of operating in this manner should not be entirely overlooked. On the other hand, if present types are merely to be modified, it should not be forgotten that the highest efficiency can be attained only by practically doubling the present-furnace temperatures increasing the percentage of CO_2 from, say, 10 to nearly 20. This doubling of furnace temperature would be associated with an enormous increase in heat transmission, since radiation from incandescent fuel increases as the fourth power of the temperature. Even under present conditions bulged and burned water tubes occur most frequently in those boilers whose efficiency is exceptionally high. In the absence of grease and scale these mishaps can only be attributed to the intense radiation from extremely hot fires.

The fan, shown diagrammatically in the upper left-hand corner, illustrates another method of securing high efficiency with moderate temperatures. The idea in this case is to take some of the chimney gases and pump them back into the boiler with the inlet air. If this were done, the furnace temperatures would correspond roughly with the volume of gases going up the chimney below the fan, while the efficiencies obtained would correspond to the smaller volume passing to waste up the stack. In cooling effect this system of operation is equivalent to adding excess air without its accompanying chimney loss.

How the American Engineering Standards Committee Works

The American Engineering Standards Committee essays to serve as a national clearing house for engineering and industrial standardization, to act as the official channel of co-operation in international standardization and to provide an information service on engineering and industrial standardization matters. The ultimate responsibility for and control of the work rests with the organizations whose representatives constitute the American Engineering Standards Committee. The process of industrial standardization may be conveniently divided into four stages: (1) Standardization by individual firms; (2) by societies and associations; (3) on a national scale; (4) on an international scale. The A.E.S.C. is primarily concerned with the last two stages. It is the agency through which industrial standardization in this country is passing from the second to the third stage, namely, from standardization by associations, societies and governmental agencies, to standardization on a national scale. Through its method and procedure, which are the result of extensive study and discussion on the part of numerous bodies concerned and which have been further developed through three years of experience, the standardization work of the many bodies concerned is being broadened and unified into a system of national industrial standards.

The A.E.S.C. method is simply a systematic plan of co-operation by which all organizations interested in any particular standardization project participate (1) in deciding whether the work shall be undertaken at all, (2) in formulating the standardization, and (3) in its ultimate approval as an "American Standard" or a "Tentative American Standard."

The formulation of each standard, including all detailed work and technical decisions, is in the hands of a working committee, called a "sectional committee." The sectional

committee is made up of representatives designated by the various bodies interested in the particular project in hand. Each sectional committee is organized by, and under the leadership of, one or more of the principal bodies interested. Such bodies are known as "sponsors." This plan makes the committee the most decentralized of all the national standardization bodies.

After the standard has been formulated and agreement upon it reached in the sectional committee, it is submitted, through the sponsor, to the Main Committee for approval. In acting on the approval of standards as "American Standards" or "Tentative American Standards," the Main Committee considers the adequacy of representation on the sectional committee of the various interests, and the procedure which has been followed, but it does not concern itself with the technical details of the standard. Hence, approval by the A.E.S.C. means, not that the Main Committee has itself worked over and passed upon the technical details of the standard, but that it has satisfied itself that all organizations concerned have had an opportunity to participate in the work, that the work has been carried out under a procedure that has been regular, open and aboveboard, and that the standard represents a real national consensus on what is best in American engineering and industrial practice, and hence that it either already does, or may reasonably be expected to, play a significant if not a controlling rôle in the processes and materials in the industry concerned.

Federal Water Power Rights

By A. L. H. Street

In the case of Waters vs. Phillips, 284 Federal Reporter, 237, lately decided by the United States Circuit Court of Appeals, Seventh Circuit, the court dealt with aspects of water power developed by the federal government as an incident to improving the navigability of a river.

It was decided that where the United States had maintained a dam for seven years without objection by riparian owners whose lands were overflowed, and where a power company, at great expense, had in the meantime erected a plant to develop the power, under lease from the government, such owners were not entitled to an injunction to require lowering of the dam at certain seasons, which would prevent operation of the plant. The court held that the land owners were limited to a claim for damages, especially in the absence of a showing of substantial injury.

Speaking in general terms, the court said:

When the United States, in the lawful exercise of its authority, builds a dam for purposes of navigation, the water power thus developed may be lawfully used by the United States, or leased to any concern engaged in the development and distribution of power or electrical current. In other words, there was no need for the potential power residing in this pond to go to waste, and we can see nothing objectionable, but everything commendable, in the policy of the government in permitting a lessee or licensee to convert such power into electrical current. U. S. v. Chandler-Dunbar, 229 U. S. 73, 33 Sup. Ct. 667, 57 L. Ed. 1063.

True, the right of the government cannot be exercised to the impairment of any right of the landowner. But such landowner's rights must be measured by the extent of the easement acquired by the sovereign in the condemnation proceedings. And where the United States government acquires the right to erect a dam to a certain height for the purpose of improving navigation, it also acquires, as an incident thereto, the right to use the pond for power purposes. In fact, it would be the usual and rare exception to find a large and expensive dam constructed and a large pondage created, without an attending power plant to utilize the potential power of the passing water.

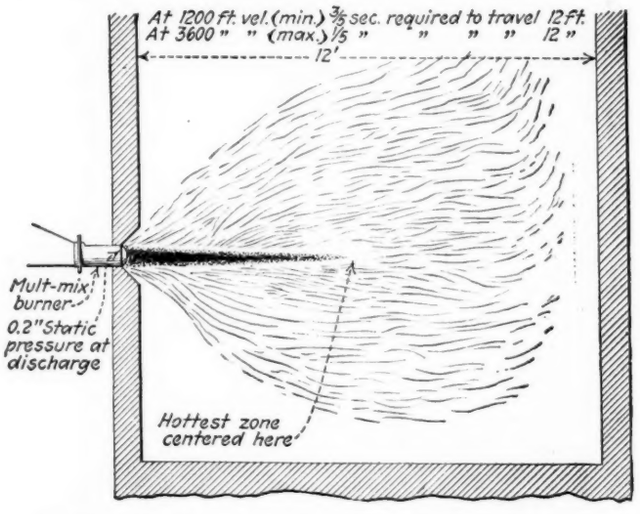
We therefore hold that, unless specifically and expressly limited, the right to erect a dam, create a pond, and overflow the adjoining land for the purpose of improving navigation carries with it the right to use the pond and the water power thereby developed for all useful purposes.

Electrician—"Watt" reaction do you get from "ohm" brew?

Engineer—Well, it has a "load factor" of about seven per cent, but it doesn't "phase" me.—*Public Utility Information Bulletin.*

Burning Pulverized Coal with Reduced Furnace Volumes

In the March 13 issue, pages 417 to 419, an abstract of a paper by M. W. Arrowood was presented. Inadvertently, an illustration drawn to show the disastrous effect of a fuel velocity into the furnace of 15,000 ft. per min. was used as Fig. 3, instead of the accompanying drawing showing the action of the fuel stream from a Multi-Mix burner of the author's design. To insure thorough commingling of fuel and air entirely within the furnace requires, according to the author, relatively high entrance velocities. When the pulverized fuel is thoroughly diffused in all of the air needed for combustion before entrance to the furnace, as is the case with the Multi-Mix burner, low velocities rang-


At 1200 ft. vel. (min.) 3/5 sec. required to travel 12 ft.
At 3600 " " (max.) 1/5 " " " " " 12 "
12'
Mult-mix burner
0.2" Static pressure at discharge
Hottest zone centered here

ILLUSTRATES FLAME WITH MULTI-MIX BURNER

ing usually from 1,500 to 2,500 ft. per min. are permissible. The action within the furnace is as explained in the abstract of Mr. Arrowood's paper. In order that there need be no further misunderstanding, it should be explained that the shape of the burner is flat, the measurements being approximately 5 in. deep by 40 in. wide.—Editor.

Choose Boiler To Fit Economiser

If an economiser is to be used, it seems highly desirable to reverse the usual procedure of proportioning it to the boiler, and instead the boiler would have to be designed to suit the economiser. The air heater, too, would be affected by the economiser. The position would be this: In the air heater the discharge temperature may not be less than, say, 140 deg. F. The hot air for the furnace should not have a higher temperature than, say, 400 deg. F. or whatever other limit may prove convenient. These two limits fix the size of the air heater and the temperature of the waste gases leaving the economiser. The size of the economiser and the temperature of the gases entering it are fixed by certain considerations. Assuming that the waste products have twenty-one times the weight of fuel burned and that seven pounds of feed are evaporated per pound of fuel, a rise in water temperature of one degree would result in a drop of about 1⅓ deg. for the waste gases. Now the feed temperature may not be less than 100 deg. and it may not be raised above the steam temperature, therefore the drop in flue-gas temperature is limited to four-thirds of this difference in temperature. This drop has to be added to 140 deg. F. and to the drop of temperature in the air heater and we arrive at the temperature of the waste gases leaving the boiler proper and its superheater. This discharge temperature practically fixes the heating surface of the boiler except in so far as it may be affected by the velocity of the gases.—*C. E. Stromeyer.*

News in the Field of Power

San Joaquin River To Have Big New Power House

Construction work on the fourth power house on the Southern California Edison Co.'s Big Creek-San Joaquin River project, known as Big Creek Number Three, and which will have the largest generating capacity of any hydro-electric power house in the West, was started by the Southern California Edison Co. on April 12.

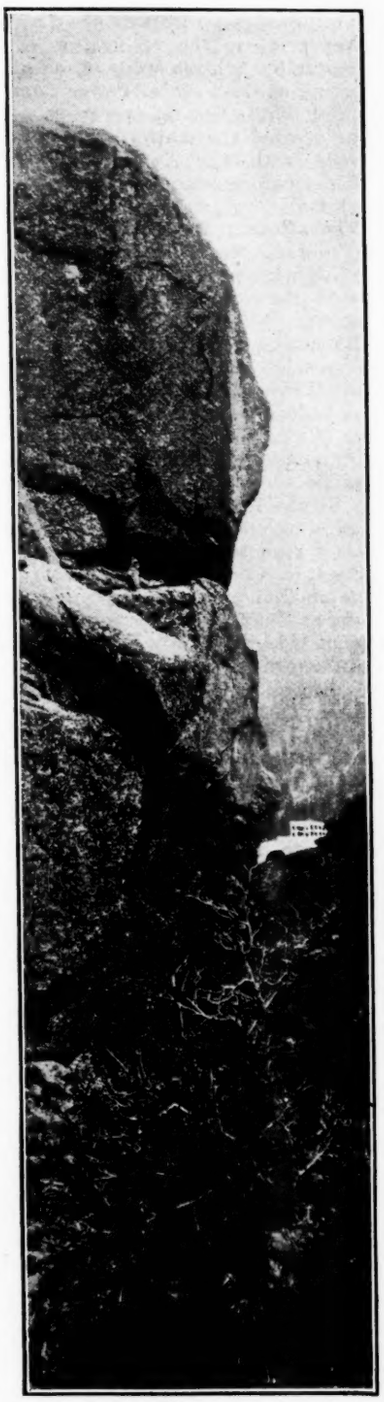
The completion of this power house will be the consummation of the fourth step in the company's Big Creek-San Joaquin project, which contemplates developing 1,407,000 hp. of electricity from the water courses of the High Sierra Mountains in Central California, at a cost of $375,000,000, or about $15,000,000 more than the Panama Canal. The cost of construction of this power house is provided for in the annual budget of the Southern California Edison Co., which appropriates $26,000,000 for hydro-electric development and apparatus and transmission and distribution lines during 1923.

The initial installation in this power house will consist of three 35,000-hp. units, which is one-half of its ultimate development. The building will be 200 ft. in length, 139 ft. in width and 110 ft. in height from the tailrace floor to the roof, and will be of reinforced concrete and structural steel. Excavation, which was carried on by means of hydraulic sluices and steam shovels, was started on June 15, 1922, and the first concrete was poured in the foundations Jan. 10, 1923. The power-house structure will contain the prime movers, but the switching station will be of the outdoor type, this being the first installation of 220,000 volts to be placed in actual operation. The generating room will be 55 ft. in width and 70 ft. high, and the building will be equipped with a 125-ton Niles crane, with a 15-ton auxiliary.

The main units will consist of three 35,000-hp. vertical turbines, built by the Wellman-Seaver-Morgan Co. These turbines will operate at a speed of 423 r.p.m. under 760 ft. head. They will be equipped with Woodward governors and will drive 25,000-kva., 50-cycle Westinghouse generators having direct-connected exciters.

One novel feature of the plant will be the omission of a separate lubricating oil system. In this installation each bearing of the main unit will have its own lubricating oil pump, thus eliminating all outside oil filters, pumps, supply tanks and piping, which are liable to cause trouble in operation.

Another novel feature of the design is the elimination of the basement in the generator room. As the plant is laid out, the operating floor will be on two levels, one at the base of the generator and the other at the elevation of the turbine, so that practically all the equipment will be in view of the operator at all times.



POWER HOUSE OF BIG CREEK NO. 3

Site of the new electric giant, 2,000 feet down the Grand Canyon of the San Joaquin River in California, as it will be seen from a point fifteen miles up the stream.

The switching station will be 195 ft. in width by 430 ft. in length and will consist of a series of concrete benches excavated on the slope of the mountain, there being a difference in elevation of 46 ft. between the upper and lower benches. These benches will support the oil switches, disconnecting switches, frames and insulated piers for carrying the bus structure.

The penstocks for the turbines will be made entirely of lap-welded pipe varying in diameter from 7½ to 6 ft., the penstock valves at the bottom of these lines being the needle-type valve manufactured by the Wellman-Seaver-Morgan Co. At the upper end of the penstocks there will be installed 7½-ft. diameter butterfly valves, arranged for control from the power house.

At the upper end of the penstocks there will be installed a manifold of special design, which will connect the six penstocks of the ultimate installation with an 18-ft. steel pipe, connecting to the tunnel, there will also be installed a surge tank excavated from the solid rock, and having a shape similar to an hour glass, the largest portion being about 75 ft. in diameter. This surge tank will relieve the penstock and tunnel line from all possibility of damage due to variations of pressure in the pipe line.

The 21-ft. diameter tunnel leading from the intake at the diversion dam to the penstocks is 30,000 ft. in length. This tunnel, excavated from the solid granite, will be unlined throughout, excepting for two or three short stretches where bad ground was encountered.

There are already in operation above this plant on the Big Creek drainage, three generating stations carrying the waters from Huntington Lake, at an elevation of 7,000 ft., to the intake of this plant. There will be an additional plant constructed directly below the Number Three plant, utilizing all the available head in the Grand Canyon of the San Joaquin River.

On the Big Creek-San Joaquin River development, in addition to these five generating stations, there will be some ten stations constructed to utilize the waters coming from the other tributaries of the San Joaquin, that are not as yet developed. On this development there is a total potential horsepower, which the company intends to develop within the next ten years, of approximately 1,250,000 hp. These plants, when completed, will utilize the waters of the entire drainage area from Mt. Hilgard, on the crest, to the San Joaquin River, a drop of two miles.

Profound Research Advised for Bureau of Standards

"It is of the highest importance to the future of American industry and scientific progress that the activities of the Bureau of Standards should continue more and more devoted to scientific research of a profound and fundamental character, beyond the means of most college laboratories, where instruction to students is the chief purpose, and that these investigations should be of a broader scope than can be expected from research and testing laboratories in the service of special industries."

The foregoing is a portion of the findings of the Board of Visitors to the Bureau after a careful survey of the establishment's current activities. The Board of Visitors is composed of John R. Freeman, former president of the American Society of Civil Engineers; Ambrose Swasey, former president of the American Society of Mechanical Engineers; F. W. McNair, president, Michigan School of Mines; S. W. Stratton, president, Massachusetts Institute of Technology, and Wilder D. Bancroft, professor of chemistry, Cornell University.

"The determination of the physical constants of materials and the more thorough investigation of the properties of substance, apart from immediate applications seen in the industries," continues the report of the Board of Visitors, "seem particularly appropriate under the organic act creating this Bureau. We venture to suggest specific appropriations in the budget for such research."

Quebec to Lease Quinze River Rapids for Power

The Quebec Provincial Government has decided to allow the utilization of one of the most important waterfalls in the province. Hon. Mr. Mercier, Minister of Lands and Forests, has announced that the Quinze River's upper group of rapids will be leased by auction April 25, 1923, at the Parliament Buildings.

The leasing of these important falls will give occasion to the Provincial Government to inaugurate a new policy as to the exportation of power developed from the waterfalls situated in the province. The Quinze River rapids are in Temiscamingue County, being the northern section of several groups of rapids on the Quinze River. Their gross capacity is 60,000 hp.

The contract which has to be signed by the successful bidders has twenty clauses or more, which are of a nature to protect the interests of the province and also allow changes to be made in the fees charged if found desirable.

In addition to the usual fee of fifty cents per horsepower developed, a special exportation tax of fifty cents per horsepower exported is also imposed. This is a new move, but is regarded as a protective measure and also a guarantee of sufficient money for the exploitation of the provincial power resources in the event of the total output of 60,000 hp. being taken across the border.

Arizona's Action Seriously Delays Power Projects

Such strenuous objections to the granting of any rights on the Colorado River prior to the ratification of the compact by Arizona were raised at the meeting of the Federal Power Commission on April 19 that the Secretary of War decided the matter should be discussed with the President and the Cabinet before action is taken upon the question.

The attorney representing the State of Colorado contended that a long line of litigation would result if, by any chance, the compact should fail of ratification.

Executive Secretary Merrill of the Commission countered with the statement that any rights granted could be qualified so as to meet that situation. Col. William Kelly, the commission's chief engineer declared that the only possible reason for delaying action on the Girand license is that the blocking of all development on the river constitutes a club to hold over Arizona.

Senator Cameron of Arizona and Senator Kendrick of Wyoming each spoke at length in opposition to any action at this time.

An attorney representing the City of Los Angeles opposed the granting of the Girand license on the ground that the development proposed at Diamond Creek would interfere with the development of power at Boulder Canyon.

The Secretary of the Interior, who is from Colorado, seemed inclined to agree with the opposition. It was very evident that Secretary Weeks favors taking action but is willing to leave the decision of so controverted a matter to the President and the Cabinet.

Failure to ratify the Colorado River Compact is regarded by Federal officials as a greater calamity to the West than is generally appreciated at present. The fourteen major projects that have been halted by the action of Arizona, if allowed to proceed, would contribute very importantly to the prosperity of the entire West. It happens that Arizona itself is affected adversely as much as, if not not more, than any other single state. The only encouraging aspect of the situation is that the compact stands and can be ratified at any time in the immediate future.

The Girand project at Diamond Creek, involving the ultimate investment of $70,000,000, from which Arizona would be practically the entire beneficiary, the Southern California Edison Co.'s project of a great reservoir at Lee's Ferry, the Flaming Gorge project of the Utah Power & Light Co. on Green River and the Denver Gas & Electric Co.'s development at Kremmling on the Colorado have all been held up and interfered with seriously by the action of Arizona.

Development of Central-Stations in Italy

Increases in Italy's central-station capacity since 1915 have been substantial, in spite of the after-effects of the war, the economic crisis, labor troubles and other handicaps. In 1915 the various central stations of the kingdom were developing, 1,520,000 hp.; at the end of 1922 the figure reached 2,170,000 hp., the increase being almost exclusively represented by the increase of hydro-electric stations.

During the years 1921 and 1922 alone there was an increase of about 300,000 hp., while 67 new hydro-electric stations entered into service, of which 15 were supplied with a total of 78,375,000 cu.m. of waters from reservoirs and artificial lakes. During this same period work was begun on 51 new plants, with aggregate hydraulic energy of 364,454 hp., and on 27 reservoirs, holding a total of 209,656,000 cu.m. of water.

In addition to these, work is about to begin on other large plants, especially in Venezia Tridentino, where in two or three years more over 3,000,000 hp. will be available. These figures were taken from the April 12, issue of *Commerce Reports.*

A Book for a Story

Jos. W. Hays, Michigan City, Ind., is arranging material for a new edition of his "Fireman's Bible"—"How to Build up Furnace Efficiency." To the new material being added to the book, he is desirous of including contributions from operating and consulting engineers, telling how combustion conditions were improved and a saving in coal effected. The new seventeenth edition will be bound in flexible imitation leather, and it is the plan to send gratis to each contributor a copy of the book upon publication.

Advice to Fuel Consumers

The experience during the last winter should demonstrate to householders the expediency and feasibility of buying and storing their next winter's requirement of coal in their nearly empty bins during the spring and summer months. This is the advice of the Federal Fuel Distributor, F. R. Wadleigh, to the coal-consuming public.

Besides the inconvenience of trying to obtain the needed fuel as it may be required, it will be cheaper, more economically handled by dealers and railroads, and users would get cleaner and better-prepared coal containing less moisture. The steady employment of labor at the mines and elsewhere would also be effected. The present wage agreement between the anthracite mine operators and the United Mine Workers expires Aug. 31, 1923, and while it is hoped and expected that there will be no stoppage of work at the mines and that a new agreement will be signed, there is still a possibility of trouble and delay, with curtailed production and unemployment as the result.

Scranton, Pa., Adopts Boiler Code

The City of Scranton by ordinance introduced in council, adopted the boiler code of the Industrial Board of Pennsylvania as effective in that city ninety days after the approval of the Mayor. The Mayor signed the ordinance on March 7, 1923. This step assures uniform boiler regulations throughout the commonwealth of Pennsylvania. The County of Allegheny and the Cities of Philadelphia and Erie, which have the right under the law, to make their own rules and regulations pertaining to steam boilers, adopted the code of the Industrial Board, which is same as the A.S.M.E. code, within the last two years.

Metropolitan Power Co., to Build New Plant

The Metropolitan Power Co., of Pennsylvania, is to build and operate a large steam-electric power-generating plant at Middletown, on the Susquehanna River. The initial capacity will be 30,000 kw., but it will be designed for extension to an ultimate capacity of 200,000 kw. The installation will also be designed for the use of powdered coal. The Metropolitan Edison Co., of Reading, will be enabled to use this steam power in conjunction with the full capacity of the present hydro-electric power station of York Haven Water & Power Co.

Wisconsin-Minnesota Light & Power Co. Expands

The Wisconsin-Minnesota Light and Power Co. has leased for a period of 30 years the hydro-electric development of the Chippewa Power Co. This plant is about 15 miles above the Wissota dam, and it is the first of the 5,000-hp. units which are to be in operation in April, 1923.

The largest hydro-electric plant of this company is at Wissota, on the Chippewa River, near Chippewa Falls. It has an installation of six units operating under a head of 57½ ft. and developing 45,000 hp. In the last year and a half a storage dam and reservoir has been constructed about 75 miles upstream from this plant for conserving the water from melting snow and impounding the flood flow of the river. The capacity of this reservoir is about 12,000,000,000 cu.ft. which will cover about 22,000 acres. This will greatly increase the output of electrical energy during the time of comparatively low water.

Susquehanna Power Co. Develop at Conowingo, Md.

A plan to install 360,000 hp.—an installation greater than that on the American side at Niagara Falls—on the Susquehanna River, is revealed by an application which has been filed with the Federal Power Commission by the Susquehanna Power Co., of New York. The proposed development is to be at Conowingo, Md. It is the intention to construct a dam 100 ft. high, which will create slack water for 25 miles to McCalls Ferry at Holtwood, Pa.

The Susquehanna Power Co. already has acquired practically all flowage rights needed for the project and has made extended engineering studies. Further investigation, however, is planned.

It is understood that Philadelphia interests are behind the undertaking. In proposing the installation of equipment sufficient to generate 360,000 hp., the company has in mind the furnishing of large blocks of power for use in Philadelphia and Baltimore.

It also is reported that the Pennsylvania Water and Power Co. has in mind the development of the power immediately above its Holtwood plant. Such a plan would develop slack water in the Susquehanna from tidewater to the vicinity of Harrisburg, and would pave the way for the utilization of these pools by a navigation project.

American Participation in British Power Conference

The committee appointed last February to consider participation by American engineers in the power conference to be held in England at the time of the British Empire Exposition next summer has instituted a movement to that end. Prominent engineering and industrial organizations and government bureaus identified with the subject are to be asked to appoint representatives to a general committee which may extend itself by the appointment of honorary and individual members from among public officials and others of especial prominence in the field of power. This general committee will meet on Wednesday, June 13, at the Engineering Societies Building, New York City, for organization and discussion of the scope, method and details of American participation.

John W. Lieb, of the New York Edison Co., is chairman and O. C. Merrill, Secretary of the Federal Power Commission, is secretary of the general committee.

Westinghouse Co., Announces War Memorial Scholarships

The Westinghouse Electric Manufacturing Co., announces that applications for the 1923 War Memorial Scholarships can be filed. Each scholarship carries with it an annual payment of $500 for a period of four years, which is to be applied to an engine ring education in any technical school or college that the candidate may select. Sons of employees of the company and its subsidiary companies who have had five years of service, or employees of the company or subsidiary companies who have had two years of service and who shall not on Sept. 1 exceed the age of 23, are eligible. Two of the four scholarships are awarded annually to successful candidates.

Petroleum Production and Stocks, January, 1920, to December, 1922

According to figures given in the American Petroleum Institute Bulletin the production of domestic crude oil increased from 443,402,000 bbl. in 1920 to 551,197,000 bbl. in 1922, an increase of 107,795,000 bbl. in the three years covered. During the same period there was imported (all oils) 108,793,837 bbl. in 1920 and 135,330,602 bbl. in 1922, an increase of 26,536,765 barrels produced.

From January, 1920, to December, 1922, Eastern wells decreased in number and output, the Gulf Coast wells decreased in number and increased in output, while the Rocky Mountain Section and California increased both the number of wells and their production or output.

Although the monthly average varied, there was practically a steady increase of stocks of pipe line and tank farm and crude oil stored from January, 1920, to December, 1922, with a total of 298,382,875 bbl. for the whole of the United States.

There was a decrease in the production of lubricating oils during these three years and also a decrease of stocks. Stocks of Mexican oils decreased from 4,866,000 bbl. in 1920 to 2,625,000 bbl. in December, 1922, and imports of Mexican crude and topped oil increased from 106,097,151 bbl. in 1920 to 129,018,439 in 1922, an increase of 22,921,288 barrels.

More detailed information in regard to oil figures can be obtained from the Bulletin of the American Petroleum Institute, 15 West 44th St., New York City.

India Adopts New Boiler Laws

The Legislative Assembly of India has passed a new bill amending their laws relating to the construction and operation of steam boilers so that a single law will apply throughout the entire country. The United States Bureau of Foreign and Domestic Commerce has applied for copies and hopes to have them available soon. Manufacturers and exporters shipping steam boilers to India should be careful to see that they comply with these new requirements which differ from former specifications.

Machinery Exported to Spanish-Reading Countries in 1921

From a recent compilation of export statistics made by *Ingeniería Internacional*, there was $2,817,898 worth of stationary engines, $3,735,212 of boilers, $4,876,934 engine parts, $6,295,802 pumps and pumping machinery, $918,873 refrigerating and ice-making machinery and $33,356,442 electrical machinery—in all $52,001,166 worth of power-producing equipment—exported from the United States to Spanish-reading countries during the year 1921.

New Publications

Interior Wiring. By Arthur L. Cook. Published by John Wiley & Sons, Inc., New York, 1923. Cloth; 4½x7 in.; 458 pages; 239 illustrations; 47 tables. Price, $3.

This is the second edition of this book, which is intended as a guide for electrical workers in modern practice of electric lighting and power applications and in the design and installation of the wiring for such purposes. The book has been revised and brought up to date to conform with the latest recommendations of the National Electrical Code. The sections dealing with tungsten and mercury-vapor lamps have been entirely rewritten to include recent developments.

The book is divided into four sections. The first, electric lighting systems, is made up of eight chapters. In the second electric-power systems are treated of and the section includes a chapter on motors for industrial purposes, one on motor-starting devices and controllers and another on selecting motors for industrial purposes. In the third section interior wiring is comprehensively dealt with in ten chapters, both alternating and direct-current systems being covered. The fourth section is composed of 47 tables giving data on illumination, motors, circuits and fittings.

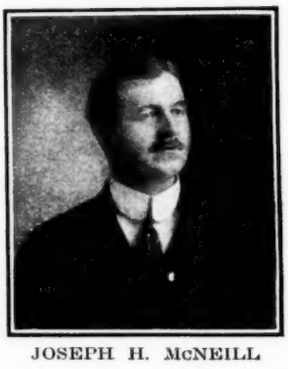
In the handling of the various subjects the author has subordinated theory to the practical and takes up the subjects where they are left off in textbooks and supplies information that is lacking in many of these books. Mathematics have been used only where necessary to practical problems. In all cases problems are worked out to show the practical applications of the calculations. The book is also adapted for use in schools, giving trade courses in electric wiring to supplement the work given in the shop. For those interested in the practical application of electric lighting and power this little volume holds a wealth of information.

Obituary

Joseph H. McNeill, Chief Inspector of the Hartford Steam Boiler Inspection & Insurance Co., died suddenly at his home, Irvington-on-Hudson, April 18, 1923, of heart failure.

He was born Feb. 14, 1865, in Charlottetown, Prince Edward Island, where he received his education in the public schools and in the Prince of Wales College. In his early life he was connected with the Prince Edward Island Railway, and he held the position of chief engineer of ocean-going vessels under licenses both from the United States government and from the British Board of Trade, and for several years was an engineer officer of the Eastern Steamship Co., sailing out of the port of Boston. Later, he was engineer of the New England Piano Co. at Cambridge, and of the Hood Rubber Co. at Watertown, Mass. He left the latter company in 1898 to enter the service of the State of Massachusetts as a boiler inspector of the District Police of the Commonwealth of Massachusetts About ten years later he became chief inspector and chairman of the Massachusetts Board of Boiler Rules. In both capacities he had much influence in shaping the laws and rules governing the construction, installation and operation of boilers.

Mr. McNeill resigned from the Massachusetts State Inspection Department on July 8, 1912, and became Chief Inspector of the Boston Department of the Hartford Steam Boiler Inspection and Insurance Co., in which position he remained until he was transferred to the New York office in May, 1915.



JOSEPH H. McNEILL

He was a member of the Board of Examiners of the Industrial Commission, Boiler Inspection Department, State of New York; A.S.M.E.; Diana Lodge A.F. & A.M., Melrose, Mass.; and Flatbush Chapter, No. 177, O.E.S., Brooklyn, N. Y.

Personal Mention

Fred J. Postel, formerly consulting engineer, has been appointed district manager of the Chicago office recently opened by McClellan & Junkersfeld, Inc., Engineers and Constructors, of 45 William St.. New York City.

William J. Ranton, of the Fidelity and Casualty Co., is on a visit to the Pacific Coast. He expects to visit all the boiler inspectors connected with the company and to renew his many pleasant connections with members of the N.A.S.E. and U.C.C. of E.

R. T. Gordon, who for the last eight years has been connected with the Alberger Pump and Condenser Co., has resigned to accept a position in the sales department of Dean Brothers Co., of Indianapolis, and will be at their New York City office, 141 Broadway.

Col. Charles Keller, an officer of the Corps of Engineers, U. S. Army, who has served for the past two years as Engineer Commissioner of the District of Columbia, has resigned to undertake important duties connected with hydroelectric development on the Pacific Coast.

Charles H. Smoot has purchased a controlling interest in the Rateau, Battu Smoot Engineering Corp., maker of the Smoot Regulator and has changed its name to the Smoot Engineering Corp., with offices at 136 Liberty St., New York City. The Rateau, Battu Smoot Company is a separate organization and still continues its business of steam turbines, turbo blowers and similar apparatus, at 90 West St., New York City.

Society Affairs

The Engineers' Club of Philadelphia, 1317 Spruce St., Philadelphia, Pa., will hold its annual meeting on May 15, 1923.

Baltimore Section of the **A.S.M.E.** will hear George A. Orrok speak on "Power Developments—Past and Future," on April 30, at the Engineers' Club.

Mid-Continent Section of the **A.S.M.E.** will hold its annual meeting at Tulsa, Okla., April 27-28. Dean Dexter S. Kimball, of Cornell. will be the principal speaker.

St. Louis Section of the **A.S.M.E.** will have a ladies' night on April 30, at Gatesworth Hotel. Dexter S. Kimball will speak on "National Leadership," after which there will be cards and dancing.

Engineers Club of Hartford is to be the name of a new club to be organized in the near future. Engineers and others interested in engineering subjects living in or near Hartford are eligible for membership. The need for more opportunity of getting acquainted with men interested in other phases of industry is one of the reasons given for the club's formation.

The A.I.E.E. plans for the Summer Convention in Swampscott, Mass., on June 26-29 are developing rapidly. Swampscott is about fifteen miles from Boston on the famous North Shore of the Bay State. The keynote of the convention will be advances in equipment and plant design. Subjects to be covered will be: Modern developments in rectifiers; researches conducted upon the nature of insulation failures; artificial transmission lines; electric plants for commercial radio; transmissions and distribution; a new type of lightning arrester; lamp quality; street lighting; and a whole session on the subject of station economies as effected by the proposed use of 1,000 lb. steam pressure at the new Weymouth station of the Edison Electric Illuminating Co., of Boston and by new methods of conducting away heat losses in generating machinery. Inspection trips, golf, tennis, surf bathing, music, cards and dancing will contribute to the social and recreational side of the convention.

Business Notes

Detroit Stoker Co. is appointing Nelson G. Phelps district manager of its New York City office at No. 2 Rector St.

The Traylor-Dewey Contracting Co., Allentown, Pa. announces that it has recently been reincorporated under the name of the Cement-Gun Contracting Co.. Allentown, Pa.

The Walter A. Zelnicker Supply Co., of St. Louis, Mo., has moved its offices from 325 Locust St., where it has been located for twenty years, to 511 Locust St., St. Louis, Mo.

The Superheater Company, 17 East 42nd St., New York City, has appointed J. S. Cothran as representative of the company for North and South Carolina, with offices at Charlotte, N. C.

Westinghouse Electric & Manufacturing Co. has appointed as manager of the Marine Sales Department, G. H. Froebel, formerly manager of the Houston, Texas, branch office.

Dwight P. Robinson & Co., Inc., are opening a new office in Philadelphia under the direction of Carl A. Baer, who is a member of the A.I.E.E. and was formerly with the firm of Baer, Cook & Co.

The Chicago Pneumatic Tool Co., of 6 East 44 St., New York City, announces that Robert F. Eissler, assistant to the vice-president, has resumed at his own request, his former position of district sales manager at Pittsburgh.

Stone & Webster, Inc., of Boston, Mass., have recently taken over the management of the Winter Haven Ice and Light Co., of Winter Haven, Florida. Thomas J. Hanlon, Jr., formerly of the Tampa Electric Co., will become manager.

The Templeton Manufacturing Co., 15 Business St., Hyde Park, Mass., manufacturer of Templeton Return and Boiler Feed Traps, is to have associated with it Henry D. Jackson and William P. Mower, formerly with Monks & Johnson.

The McClave-Brooks Co., is opening a branch office in St. Louis at 276 Arcade Bldg., under the management of William C. Smith, who will look after the customers in eastern Missouri and southern Illinois. The Harvill Supply Co., 315 Chamber of Commerce Bldg., Nashville, Tenn., will represent the company in that city.

Stone & Webster, Inc., make the following announcements: Tom P. Walker, formerly with the Haverhill, Mass., Gas Light Co., is now manager of the Baton Rouge (La.) Electric Co.; J. L. Alexander, formerly manager of the Keokuk (Iowa) Electric Co., is to be in charge of the Haverhill (Mass.) Gas Light Co.; Walter H. Burke, who has been in the firm's Boston office will succeed Mr. Alexander as manager in Keokuk.

Coming Meetings

American Association of Engineers; C. E. Drayer, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

American Boiler Manufacturers' Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Thirty-fifth Annual Convention at Hot Springs, Va., June 4-6.

American Institute of Electrical Engineers; F. L. Hutchinson, 29 West 39th St., New York City. Spring meeting at Pittsburgh, Pa., April 24-26.

American Order of Steam Engineers; W. J. Brice, 1428 Callowhill St., Philadelphia, Pa. Annual convention at Philadelphia, June 4-8.

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Spring meeting at Montreal, Canada, May 28-31.

American Society of Refrigerating Engineers; W. H. Ross, 154 Nassau St., New York City. Spring meeting at St. Louis, Mo., April 30, May 1-2.

American Water Works Association, 163 W. 71st St., New York City. Annual meeting at Detroit, Mich., May 21-25.

American Welding Society, 29 W. 39th St., New York City. Annual meeting at New York City, April 24-27.

Canadian Association of Stationary Engineers; Gordon C. Keith, 51, Wellington St. West, Toronto, Canada. 34th annual convention at Toronto, Canada, June 25-28.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

International Railway Fuel Association; J. G. Crawford, 702 East 51st St., Chicago. Annual meeting at Cleveland, Ohio, May 21-24.

National Association of Cotton Manufacturers, Providence - Biltmore Hotel. Annual Meeting, Providence, R. I., Apr. 24-25.

National Association of Manufacturers; George S. Boudinot, 50 Church St., New York City. Annual conference, New York City, May 14-16.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Indiana,** at La Fayette, Ind., May 28-29; T. J. Kelly, 2704 South St., La Fayette, Ind. **New Jersey,** at Trenton, N. J., June 1-3; Samuel Clark, 67 Columbia St., Jersey City, N. J. **Illinois,** at Springfield, Ohio, June 6-9; F. W. Raven, 417 South Dearborn St., Chicago. **New England States Association,** at Manchester, N. H., July 12-14; James F. Morgan, 53 Devonshire St., Boston, Mass. **Michigan,** at Flint, Mich., July 18-20. E. C. Smith, 208 Vine St., Kalamazoo.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Annual convention at Lake Placid Club, Essex Co., N. Y., May 29-31.

The Westinghouse Electric & Manufacturing Co. and associated companies are to have a new home in a 23-story bank and office building, to be known as the Westinghouse Building, at Broadway and Liberty Sts., New York City. The building will front 96 ft. on Broadway and 135 on Liberty St. They expect to move in on the first of May, 1924.

Trade Catalogs

Drills and Reamers—Hisey-Wolf Machine Co., Cincinnati, Ohio, Bulletin No. 106. Illustrations and text describing portable electric drills and reamers.

Strainer—Blackburn-Smith Corp., 103 Park Ave., New York City. Bulletin R-70 describes their new strainer, for straining solids from water, oils and other liquids.

Public Utility Booklet—Standard Gas and Electric Co., Chicago, Ill. Industrial activities and community growth in 16 states of the Middlewest, West and South are causing an increase of 39 per cent in the electric power resources of the operated utilities of Standard Gas & Electric Co., according to a new illustrated booklet being distributed by H. M. Billesby & Co. These companies now supply service to 562,-500 customers. Their growth is shown in graphic charts. Air pictures are presented of Minneapolis, St. Paul, Louisville, Oklahoma City, Muskogee, Pueblo, Mobile, Tacoma, Stockton and San Diego.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Apr. 9, 1923	Apr. 16, 1923
Pool 1,	New York	$3.50–4.50	$3.50–4.50
Smokeless,	Columbus	4.00–4.50	4.00–4.50
Clearfield,	Boston	2.35–3.50	2.40–3.50
Somerset,	Boston	3.00–3.75	3.00–3.75
Kanawha,	Columbus	2.25–2.75	2.00–2.50
Hocking,	Columbus	2.00–2.25	2.00–2.25
Pittsburgh No. 8	Cleveland	2.15–2.30	2.15–2.35
Franklin, Ill.,	Chicago	3.00–3.25	3.00–3.25
Central, Ill.,	Chicago	2.00–2.25	2.00–2.25
Ind. 4th Vein,	Chicago	2.75–3.00	2.75–3.00
West Ky.,	Louisville	1.75–2.00	2.00–2.25
S. E. Ky.,	Louisville	2.40–3.25	2.50–3.00
Big Seam,	Birmingham	2.00–2.25	2.00–2.25

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—April 19, Port Arthur light oil, 22@25 deg. Baumé, 5⅛c. per gal.; 30@35 deg., 5⅜c. per gal., f.o.b. Bayonne, N. J.

Chicago — April 14, 24@26 deg. Baumé, $2.12 per bbl.; 32@36 deg., $2.33 per bbl. tank cars.

Philadelphia—April 16, 26@28 deg. Baumé, Oklahoma, $1.05@$1.10 per bbl.; 30@34 deg., Oklahoma (group 3), 3¼@3⅜c. per gal.; 16@20 deg. Seaboard, $1.50@$1.60 per bbl.

St. Louis—April 10, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2 per bbl.; 26@28 deg., $2.05 per bbl.; 28@30 deg., $2.15 per bbl.; 32@36 deg., gas oil, $2.25 per bbl.; 36@40 deg., distillate $2.40 per bbl.

Pittsburgh—April 13, f.o.b. local refinery, 30@34 deg., fuel oil, 5⅜c. per gal.; 36@40 deg., fuel oil, 6c. per gal.; 34 deg., neutral, 9⅜c. per gal.

Dallas—April 14, f.o.b. local refinery, 26@30 deg., $1.61 per bbl.

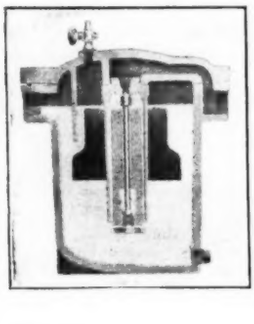
Condensed-Clipping Index of Equipment

Condensed from previous descriptions in "Power" for convenient filing

Loader, Portable "Power," 1923.
Barber-Greene Co., Aurora, Ill.

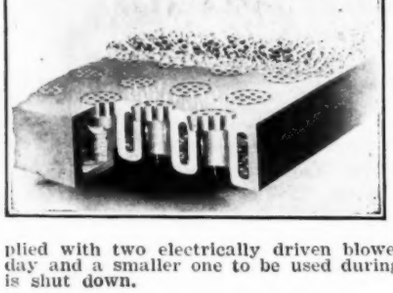
The Model 42 Barber-Greene portable loader is designed to move coal, ashes, cinders, etc., from the storage pile directly into trucks, wagons or conveyors. It is especially adapted to rapid movement of coal that has caught fire in storage. Rated at 1¾ cu.yd. per min., the loader has hauled as much as 2.4 cu.yd. of cinders a minute. It has two rotating disks at the front which dig into the pile, feeding the material into the malleable-iron buckets, of which there are twenty-five. To receive the discharging material, a swinging spout is provided and a measuring hopper of variable capacity may be used. Traction and steering are effected by caterpillars, one on either side, and power is supplied by a four-cylinder 35-hp. truck-type motor. Control of the entire machine is centralized at the driver's platform.

Trap, Steam "Power," 1923.
McKee-Wright Co., Atlanta, Ga.



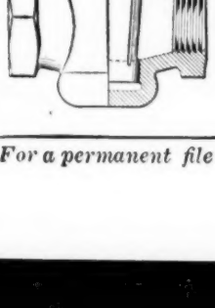
This type was designed for pressures from 1 to 250 lbs. and has but two moving parts—the bucket and the valve. Steam and condensate enter at the left. When enough water has overflowed into the bucket, it sinks and engages the shoulder on the valve stem, pulling the valve open against steam pressure and permitting discharge of the water in the bucket. At no time is the weight of the bucket supported by the valve, since the bucket floats free of the valve stem and does not engage it until the instant of discharge. There is therefore no tendency toward wire-drawing. The casing and cover are made of cast iron, the bucket of spun copper and the valve of bronze for low pressures and of monel metal for high pressures with superheat.

Grate "Power," 1923.
Culm-Burn Equipment Co., Inc., 36 South 7th St., Philadelphia, Pa.



This is a patented, water-cooled grate, designed to burn low-grade fuel such as screenings, barley, rice and river-coal. The grate is a solid casting with cored passages for the circulating of water and in the air passages are inserted renewable plugs, the last containing a number of small openings. This provides ample passage for the air without permitting the sifting through of fine coal. Each grade is supplied with two electrically driven blowers, a larger one for the day and a smaller one to be used during the night when the fire is shut down.

Valve, Lubricated Plug "Power," 1923.
Homestead Valve Manufacturing Co., Homestead, Pa.



The Homestead lubricated quarter-turn valve, of the plug-cock type, may be fitted with Alemite or Madison-Kipp oil cups. Oil or grease is forced down through the stem to lubricating grooves on the face of the plug, whence it is spread over the seating surfaces when the plug is turned on its seat. A double ball-check valve prevents backing up of oil, due to pipe-line pressure. Special lubricants for all conditions have been prepared. The valve is made in all sizes up to 6 in. and for pressures up to 350 lb. per sq.in. It is particularly adapted to high temperatures. The cam construction has been changed so that the plug is held tightly on its seat at all times, being easily turned, however. No adjustments are necessary.

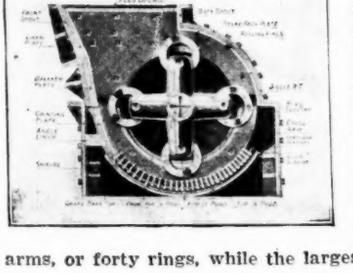
Gage-Glass Protector "Power," 1923.
Defender Automatic Regulator Co., St. Louis, Mo.

The "Defender" adjustable gage-glass protector may be attached to any water gage. There are three plates of heavy glass in each protector, affording complete protection to operators in case of gage-glass explosions. When once installed, the protector may be removed and replaced with one hand, without the use of tools. Either plain or wire glass, ⅜ in. thick, is used.

Purifier, Centrifugal Oil "Power," 1923.
Industrial Products Co., Goshen, Ind.

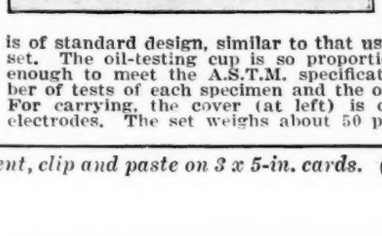
The "Hydroil" oil purifier removes dirt and water from oil by centrifugal action. Purified oil is discharged from the upper spout and water from the lower. Oil may be treated in batches, or the purifier may be piped into the lubricating system for continuous service. The vertical shaft is driven by a ¼-hp. motor through a worm and wheel, the worm being mounted on the spindle. The machine may be used also for increasing the dielectric strength of transformer oil, by the substitution of a "dehydrating" bowl, at small cost.

Crusher, Coal "Power," 1923.
American Pulverizer Co., 18 Austin St., St. Louis, Mo.



For crushing coal to various stoker sizes, this ring crusher is provided with graded openings and an adjustable shield for covering those openings when not in use. The rings are carried on crossarms mounted on the shaft. The capacities range from 25 tons an hour (requiring 10 hp.) to 400 tons (requiring 100 hp.), at 550 to 600 r.p.m., for crushing run-of-mine coal to 1¼-in. size in one operation. For ¾-in. production, the capacity is one-half these values. The smallest size has ten crossarms, or forty rings, while the largest has twice these numbers.

Oil-Testing Set, Portable "Power," 1923.
General Electric Co., Schenectady, N. Y.



The G-E portable oil-testing set is used to determine the dielectric strength of transformer oil, such a test being an indication of the presence of moisture. Because of its portability, the set may be used at the time transformers are being filled. Current is taken from any 110-volt lighting circuit and voltages of 15 to 25 kv. are obtained by means of a switch on the cover. The transformer is of standard design, similar to that used in the "Coolidge" X-ray set. The oil-testing cup is so proportioned that only one pint is enough to meet the A.S.T.M. specifications, as to both the number of tests of each specimen and the oil level over the electrodes. For carrying, the cover (at left) is clamped over the cup and electrodes. The set weighs about 50 pounds.

For a permanent file of new and improved power-plant equipment, clip and paste on 3 x 5-in. cards. (Patented Aug. 20, 1918.)

New Plant Construction

PROPOSED WORK

Ala., Tuscaloosa—The Tuscaloosa Ry. & Facilities Co. is in the market for ice manufacturing and cold storage equipment.

Ark., Flippin—The Flippin Gin Co. is in the market for a 60 hp. double cylinder oil engine.

Ark., Fort Smith—W. L. Winters, Engr., will receive bids until Apr. 26 for the construction of a pump house and filtration plant, including well filters, electric motors, valves, hydrants, repairing reservoir, etc.

California—The Bank of Italy, Powell and Eddy Sts., San Francisco, plans to build 1 to 12 story branch banks and office buildings at various points in Southern California. Cost between $5,000,000 and $10,000,000.

Calif., Glendale—The Ambronini Hotel Co., Los Angeles, is having plans prepared for the construction of a 5 story apartment hotel, here. G. M. Lindley, Amer. Bank Bldg., Los Angeles, Archt. Equipment detail not reported.

Calif., Long Beach—A syndidcate represented by the W. Horne Co., 254 East Broadway, is having plans prepared for the construction of a 13-story store and office building on 3rd and American Sts. Cost will exceed $500,000. Beelman & Curlett, Union Bank Bldg., Los Angeles, Archts. Equipment detail not reported.

Calif., Los Angeles—I. C. Frued, c/o Walker & Eisen, Archts., Finance Bldg., is having plans prepared for the construction of a 13 story office building on Hill St. Cost will exceed $500,000. Equipment detail not reported.

Calif., Los Angeles—R. Garvey, et al., c/o E. Bergstrom, Archt., Citizens Natl., Bank Bldg., are having plans prepared for the construction of a 14 story office building on Broadway near 2nd St. Equipment detail not reported.

Calif., Los Angeles—A local syndicate is having plans prepared for the construction of a 13 story, 99 x 224 ft. office building on 9th and Hill Sts. Estimated cost $2,000,000. Postle Co., Van Nuys Bldg., Los Angeles, Archts. Equipment detail not reported.

Calif., Los Angeles—R. Stern c/o E. M. Frazier, Archt., 2401 West 6th St., is having plans prepared for the construction of a 10 story store and office building on Hollywood and Vine Sts. Cost will exceed $500,000. Equipment detail not reported.

Calif., Marysville—W. C. Lowe, Archt., Monadnock Bldg., San Francisco, is preparing preliminary plans for the construction of a 6 story hotel, here. Estimated cost $300,000. Owner's name withheld.

Calif., Pasadena—The Pacific Southwest Trust & Savings Bank, Los Angeles, is having plans prepared for the construction of an 8 story, 150 x 200 ft. bank and office building, here. Curlett & Beelman, Union Bank Bldg., Los Angeles, Archts. Equipment detail not reported.

Conn., Colebrook River (Colebrook P. O.)—The Farmington River Hydro-Electric Co., Winsted, R. C. Ward, Secy., plans to build a hydro-electric station 3,600 hp., also dam, 400 ft. long and 25 ft. high, here. Estimated cost $150,000 and $600,000. Private plans.

Conn., Hartford—The Bd. of Contract & Supply, Municipal Bldg., will receive bids until May 5 for the construction of a 3 story high school on Maple Ave. and Benton St. Estimated cost $1,200,000. J. R. Worcester & Co., 79 Milk St., Boston, Engrs. E. T. Willey, 75 Pratt St., Hartford, Archt. Equipment detail not reported.

Conn., New Britain—The State Bd. Educ., Capitol, Hartford, plans to build a 60 x 80 ft. power house at Camp School in connection with the State Normal School, here. Estimated cost $40,000. Engineer or architect not selected.

Fla., Mount Dora—The city will hold election May 12, to vote $40,000 bonds for the construction of an electric light plant.

Fla., Pensacola—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will received bids until May 2, for the construction of a pump house, piping and equipment. Noted Mar. 6.

Fla., Sarasota—A. McAnsh, 2088 South La Salle St., Chicago, plans to build a hotel on Central Ave., here. Estimated cost $350,000.

Ga., Eatonton—The Putman Mills & Power Co. plans the construction of a new power plant here to have initial capacity of 750 hp. Estimated cost $65,000.

Ill., Chicago—P. T. Johnstone, Archt., 190 North State St., is preparing plans for the construction of a 5 story, 50 x 95 ft. apartment hotel, including steam heating system, on Kenmore and Bryn Mawr Sts. Estimated cost $350,000. Owners name withheld.

Ind., South Bend—Straus Bros. Co., 10 South La Salle St., is having plans prepared and will probably receive bids in June for the construction of an 8 story, 99 x 165 ft. store and office building on Michigan St. and Jefferson Blvd. Estimated cost $750,000. H. B. Beidler, c/o owner, Archt. Equipment detail not reported.

Ia., Muscatine—The Bd. of Electric Light Trustees will receive bids until April 25, for the construction of municipal electric power plant and distribution system. Date postponed from April 18. Noted April 3.

Mass., New Boston—The Farmington River Hydro-Electric Co., Winsted, Conn., R. P. Ward, Secy., plans to build a 2,000 hp. power plant, also dam, 20 ft. high and 200 ft. long, for a reservoir, 600,000,000 gal. capacity, here. Estimated cost $150,000 and $500,000 respectively. Private plans.

Mich., Detroit—Kohner & Seeler, Archts., 405 Kresge Bldg., are receiving bids and will open same about May 1 for the construction of a 10 story, 100 x 150 ft. hotel, including steam heating equipment with boilers and accessories, on John R. St. Estimated cost $350,000. Owner's name withheld.

Mich., Detroit—Varney & Varney, Archts., 1422 Washington Blvd., are preparing plans for the construction of an 8 story, 63 x 90 ft. hotel, including steam heating system, on Park Blvd. Estimated cost $250,000. Owner's name withheld.

Minn., St. Charles—The city is having plans prepared and will receive bids about May 1, for well and pumping equipment. C. L. Pillsbury Co., 1200 Second Ave. S., Minneapolis, Engr.

Mo., Columbia—Missouri University has had preliminary sketches made for the construction of a 3 and 4 story, 100 x 200 ft. hospital, including an administration building, nurses' quarters, a 100 bed surgical unit and a 100 bed medical unit on the Missouri University Campus. Estimated cost $500,000. Jamieson & Spearl, Arcade Bldg., St. Louis, Archts.

Mo., Hillcrest—(Rill P. O.)—The Concordio Seminary Assn., South Jefferson Ave., St. Louis, is having plans prepared for the construction of a group of about twenty 2 and 3 story seminary buildings on a 71 acre site, near here. Cost will exceed $2,000,000. Day & Klauder, Franklin Bank Bldg., Phila., Pa., Archts. Equipment detail not reported.

Mo., Kansas City—The Reyburn Eng. & Constr. Co., 609 Waldheim Bldg., will build a 7 story, 150 x 150 ft. hotel on 37th St. and Broadway. Estimated cost $250,000. Equipment detail not reported.

Mo., Marshall—The state plans to build a storage and ice plant at the Colony for Feeble Minded, here, A. Topping, Supt. Estimated cost $15,000.

N. J., Kearny—The Public Service Electric Co., T. N. McCarter, Pres., Newark, plans the construction of a super-power station, initial capacity about 200,000 hp., ultimate capacity about 400,000 hp. here. Estimated cost to exceed $20,000,000.

N. J., Overbrook (Verona P. O.)—Essex Co. is having plans prepared for the construction of a 3 story, 50 x 450 ft. reception hospital and a 2 story, 80 x 450 ft. convalescent hospital, including heating and ventilating systems, here. Estimated cost $1,000,000. Runyon & Carey, 843 Broad St., Newark, Engrs. F. S. and S. E. Sutton, 402 Broad St., Newark, Archts.

N. J., Waldwick—The borough, W. R. Evans, Jr., Borough Clk., will receive bids until Apr. 30 for laying 6.7 mi. of water pipe and construction concrete reservoir, dykes, dams and foundations for power house and pumping station, also for driving two or more artesian wells. J. L. Cellins, 30 Church St., New York, Engr.

New York—The Power Corp. of New York, Trust Co. Bldg., Watertown, is having plans prepared for the hydro electric development at Stark Falls, on Racquette River, St. Lawrence Co., 28,000 hp., 450 ft. head. W. P. Creager, Ch. Engr.

N. Y., Albany—The Albany Lodge of Elks., c/o E. N. Scheiberling, 95 State St., plans to build a 14 story office and club building at 138-140 State St. Estimated cost $1,000,000.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., is having plans prepared for the construction of school buildings, P. S. 97 on Benson St. and 25th Ave., P. S. 63 on Hinsdale St. near Liberty Ave., a 5 story high school building on Classon Ave. and Union St., and an addition to P. S. 145 on Central Ave. and Nole St., including steam heating systems here. Estimated cost $800,000, $750,000, $3,000,000 and $600,000 respectively. W. H. Gompert, Flatbush Ave. Extension and Concord St., Brooklyn, Archt.

N. Y., New York—Polsky & Goldstein, c/o G. F. Pelham, 200 West 72nd St., Archts., will build by separate contracts a 15 story, 85 x 100 ft. hotel at 111 East 89th St. Estimated cost $1,000,000. Equipment detail not reported.

N. Y., New York—The Protestant Episcopal Church, D. C. Pelton, Rector, c/o P. C. Hunter, 191 9th Ave., Archt., is having plans prepared for the construction of two 5 story, 90 x 159 ft. apartment buildings on Morris Ave. Estimated cost $250,000 each. Equipment detail not reported.

N. Y., New York—The 620 Park Ave. Corp., c/o J. E. Carpenter, Engr. and Archt., 598 Madison Ave., is having plans prepared for the construction of a 50 x 100 ft. apartment hotel on Park Ave. and 65th St. Estimated cost $800,000. Equipment detail not reported.

N. Y., Poughkeepsie—The city received bids for the reconstruction of pumping station from L. Chevalier, Inc., 207 East 43rd St., New York, $34,882; W. W. Kingston, 1 Washington St., Poughkeepsie, $34,994.63; L. M. Neckerman, 103 Park Ave., $36,590.40. Hazen & Whipple, 25 West 43rd St., Engrs. Noted Apr. 3.

N. Y., Schenectady—The Adirondack Power & Light Corp., 511 State St., plans to build a power station at Stop 12, Schenectady and Albany Rd. Estimated cost $75,000.

N. Y., Schenectady—The Bldg. Com. of the Chamber of Commerce plans to build a hotel to contain 215 rooms. Estimated cost $1,000,000.

N. Y., Syracuse—The Syracuse Lighting Co., 339 South Warren St., J. C. DeLong, Pres., plans to build a gas making plant. Estimated cost $3,000,000.

N. C., Burlington—The Burlington Hotel Corp., R. L. Holt, Pres., plans to build a 6 story, 98 x 131 ft. hotel on Main and Maple Sts. Estimated cost $250,000. H. Hartman, Greensboro, Archt. Noted Oct. 17, 1922.

N. C., Oakboro—The Oakboro Cotton Mill Co., J. A. Grooves, Albemarle, Pres., plans to build a 6,000 spindle cotton mill, here. Machinery will be electrically driven. Estimated cost $250,000.

N. C., Oteen—The Treas. Dept., J. A. Wetmore, Acting Supervising Archt., Wash., D. C., will receive bids until May 7, for removing two boilers, etc., and furnishing and installing two horizontal return tubular, high-pressure, steam boilers with hand stokers, at the U. S. Veterans' Hospital, here.

N. C., Raleigh—The State Bldg. Com., R. S. Bushbee, Chn., will receive bids until Apr. 30 for the construction of three cottages, gymnasium, library, cold storage and industrial buildings at the State School for the Blind. Estimated cost $325,000. J. A. Salter, 102 West Hargett St., Raleigh, Archt.

Ohio, Akron—The Akron Savings & Loan Co., c/o A. Hopkins, Engr. and Archt., 101 Park Ave., New York, is having plans prepared for the construction of a 21 story bank and office building, here. Equipment detail not reported.

O., Cincinnati—The Western & Southern Life Insurance Co., 4th St. and Broadway, is having plans prepared for the construction of a 12 story, 90 x 94 ft. office building. Estimated cost $600,000. H. Hake, Telephone Bldg., Cincinnati, Archt. Equipment detail not reported.

Ohio, Cleveland—C. Kleinman and M. B. Abrams, 309 Soc. for Savings Bldg. plan the construction of a 3 or 4 story apartment building on East 85th St., south of Euclid Ave. Estimated cost $500,000.

Ohio, Cleveland Heights (Warrensville P. O.)—The Bd. Educ., 1805 Lee Rd., Cleveland, C. Roche, Clk., is having plans prepared for the construction of a 3 story Junior High School, including steam heating system, on Cedar and Lee Rds., here. Estimated cost $1,000,000. F. C. Warner, Hippodrome Annex Bldg., Cleveland, Archt.

Ohio, Cleveland Heights (Warrensville P. O.)—The Heights-Fairmount Co., c/o G. W. Hale, 627 Hanna Annex, Cleveland, is having plans prepared for the construction of a 6 story apartment house on Cedar Rd. and Fairmount Blvd., here. Estimated cost $750,000. H. T. Gaffrey, c/o owner, Archt. Equipment detail not reported.

Ohio, Oakwood (Dayton P. O.)—The village, A. C. Stolz, Mayor, Dixon Ave., voted $50,000 bonds for the construction of a water pumping plant and laying of additional mains.

Pa., Holmesburg Junction (Phila. P. O.)—The Viscose Co., Marcus Hook, plans to build various factory buildings for the manufacture of artificial silk, along the Delaware river, here. Estimated cost $4,000,000. Private plans.

Pa., Meadville—The Chamber of Commerce, c/o E. P. Cullum, plans to build a hotel. Cost will exceed $250,000. Engineer or architect not selected.

Pa., Phila.—The Brandle & Smith Co., 8th and Dauphin Sts., will soon receive bids for the construction of a 4 story confectionery plant, on 5th and Bristol Sts. Estimated cost $1,000,000. Private plans. Equipment detail not reported.

Pa., Phila.—A. H. Brockie, Archt., 254 South 15th St., will soon receive bids for the construction of a 3 story hospital building on Penn St. and Chelten Ave. for the Germantown Hospital, Penn and Chew Sts. Estimated cost $250,000. Equipment detail not reported.

Pa., Phila.—W. Steele & Sons, 219 North Broad St., will soon receive bids for the construction of a 10 story, 124 x 134 ft. office building on 15th and Cherry Sts. Estimated cost $1,000,000. Private plans. Equipment detail not reported.

S. D., Conde—The city will receive bids until Apr. 28 for the construction of a water works system, including 2 mi. of 4 to 8 in. c.i. main, 60,000 gal. elevated tank, 75,000 gal. concrete reservoir, 6 x 8 triplex pump, etc. Dakota Eng. Co., Mitchell, Engrs.

S. D., Pierre—The city, E. B. Peterson, Auditor, is having plans prepared and will receive bids in May for the construction of an electrical distribution plant. Estimated cost $25,000. C. L. Pillsbury Co., 1200 Second Ave. S., Minneapolis, Min. Engr.

Tenn., Chattanooga—The Atlantic Ice & Coal Co., 213 Fort St., plans to build a 4 story, 80 x 140 ft. cold storage plant on 13th St. Estimated cost $150,000.

Tenn., Chattanooga—The Roane Iron Co., Chamberlain Bldg., is in the market for complete equipment for 1500 kw. electric power plant.

Tex., Dallas — The Sutton, Steele & Steele, Inc., O. Steele, Supt. and Engr., Forney Ave., has plans made and will receive bids about July 1, for the construction of a 1 story, 100 x 350 ft. steel mill, with electric furnace, 6 ton capacity. Estimated cost $125,000.

Tex., Denison — The Denison Hotel Co., c/o Chamber of Commerce, has had plans prepared for the construction of a 6 story, 120 x 150 ft. hotel on Main St. Estimated cost $300,000. Engineer or architect not announced. Equipment detail not reported.

Tex., Edgewood—The city voted $15,000 bonds for the construction of an electric light plant.

Tex., San Antonio—The Baptist Church is having plans prepared and will receive bids about July 1 for the construction of a 3 story hospital, (first unit), estimated cost $250,000, ultimate cost $1,000,000. W. H. Noonan, Moore Bldg., San Antonio, Archt. Equipment detail not reported. Noted Sept. 12.

Wash., Aberdeen — A. H. Albertson, Archt., Henry Bldg., Seattle, will receive bids until about July 1 for the construction of a 5 story, 100 x 130 ft. hotel, here, for the Washington Hotel Co. Estimated cost $350,000. Equipment detail not reported.

Wash., Millwood — The Inland Empire Paper Co. is having plans prepared for improvements in their plant and are contemplating the damming of Spokane River and development of all the power required to operate the plant. Private plans.

Wash., Olympia—The State Capitol Bldg. Com. will receive bids until May 8, for the construction of capitol building as far as base of dome, including first four divisions of building schedule. Estimated cost $1,500,000.

W. Va., Logan — The Guyan Machine Shops, B. Shell, Purch. Agt., are in the market for 5, 10 and 15 hp. motors, 3 phase, 60 cycle, 220 volt, 1,200 and 1,800 r.p.m.; pulleys or drums for 36 in. belt, about 30 in. diam.; conveyors and conveyor fittings for handling run of mine coal, belts 36 and 42 in. wide; one conveyor 24 in. belt, 10 ft. center to center of pulleys; 1,000 lb. capacity high speed elevator to be operated from 36 x 48 ft. platform, driven with motor 220 volt, 3 phase, 60 cycle, for 3 story building.

Wis., Chippewa Falls—The County Bd., J. R. Harris, Clk., has appropriated funds for a steam heating plant, including boilers, for the County Asylum. Estimated cost $25,000. Engineer or architect not selected.

Wis., Little Chute—The village, M. Van Hoof, Clk., voted $120,000 bonds for installing waterworks system, including pumping station, mains, etc. Engineer not selected.

Wis., La Crosse—O. A. Merman, Archt., Linker Bldg., will soon award the contract for the construction of a 1 story, 50 x 100 ft. power house and laundry for the Lutheran Hospital, 1910 South Front St. Estimated cost $60,000. Two 150 hp. boilers and laundry machinery will be installed. Noted Feb. 6.

Wis., Mayville — The First Methodist Church, c/o R. O. Douglas, is having plans prepared for a steam heating plant, including boilers, for church building. J. E. Hennen, 74 South Main St., Fond du Lac, Archt.

Wis., Milwaukee—Rosman & Wierdsma, Archts., 424 Jefferson St., will receive bids until Apr. 30 for the construction of a 6 story, 130 x 172 x 186 ft. apartment hotel on Grand Ave. Estimated cost $800,000. Former contract rescinded. Owner's name withheld. Equipment detail not reported.

Wis., Wauwatosa — Cahill & Douglas, Engrs., 217 West Water St., Milwaukee, will soon award the contract for the construction of a 2 story, 47 x 62 ft. power house on State St., here, for the Forsyth Leather Co. Estimated cost $40,000. Noted Jan. 30.

Ont., Elmira—The city council plans the construction of a reservoir, extension of mains, additional hydrants and installation of a new motor pump. Estimated cost $30,000. Want prices on materials and equipment. J. H. Ruppel, Engr.

Ont., Hamilton—The Canadian Westinghouse Co., P. J. Myler, Pres., plans large extensions to plant. Estimated cost $1,000,00.

Ont., Hamilton—H. McCann, 158 Wilson St. is in the market for one Mussle electric furnace, 12 x 8 x 19, 25 cycle, 110 volts.

Ont., London — The Utilities Comn. is having plans prepared for the construction of new substations. Estimated cost $77,000. E. V. Buchanan, Hydro Offices, London, Engr. The owner is in the market for switching equipment.

Ont., South Porcupine—Tisdale Twp., W. H. Wilson, Clk., South Porcupine, is having plans prepared for the construction of a pumping plant and distribution system. Estimated cost $250,000. J. F. Henderson, Timmins, Engr.

Ont., Toronto—The Canadian National Railways, New Union Sta., plan to build a 25 story or more, 100 x 140 ft. office building, including vacuum steam heating system, on King and Yonge Sts. Estimated cost $2,000,000. A. F. Stewart, 407 Old Union Sta., Ch. Engr.

Ont., Toronto—The city is having plans prepared for the construction of a 3 story hospital, including steam heating system, on Surrey Pl. Estimated cost $400,000. W. Price, City Hall, Archt.

Ont., Toronto—Yolles & Rottenberg, Ltd., 366 Adelaide St., W., are having plans prepared for the construction of a 10 story, 100 x 150 ft. textile manufacturing building on York and Front Sts. Estimated cost $1,000,000. Private plans. Equipment detail not reported.

Que., Hull—The City Council will soon receive bids for a 450 hp. electric motor for pumphouse. Estimated cost $8,000. T. Lanctot, City Hall, City Engr.

CONTRACTS AWARDED

Calif., Oceanpark—The Casino Bldg. Co. awarded the contract for the construction of a 5 story store and office building on Marine St. to Stradley & Newton, Detwiler Bldg., Los Angeles. Cost will exceed $750,000. Equipment detail not reported.

Calif., Yuba City—The city, C. C. Kline, Clk., awarded the contract for 2 pumping plants 400 to 500 g.p.m. each in connection with new sewerage system to Latourette Fical Co., 907 Front St., Sacramento, $13,112. Noted March 27.

D. C., Washington—The Potomac Electric Co., 231 14th St., awarded the contract for the design and construction of a 4 bay extension to Bennington Power Station to Stone & Webster, 147 Milk St., Boston ,Mass. Additional equipment to include 3 boilers and one 20,000 kw. turbogenerator with necessary auxiliaries, new coal handling equipment will be installed. Noted April 10.

Fla., St. Petersburg—The Mason Hotel Co. awarded the contract for the construction of a 9 story hotel on 4th St. and 1st Ave., N., to the Inglis Iron & Steel Co., 720 Ave. D, Birmingham, Ala. Equipment detail not reported.

Ill., Chicago—The Holy Angels Guardian Orphanage, 2001 Devon Ave., awarded the contract for the construction of a 1 and 3 story, 120 x 209 ft. power plant and shop to J. Gebhardt & Son, 111 West Washington St., Chicago. Estimated cost $150,000.

Ind., Mishawaka—The city awarded the contract for the construction of a concrete reservoir, 1,500,000 gal. capacity, to J. W. Martin, 420 Bd. of Trade Bldg., Indianapolis, $28,793; a motor driven centrifugal pump unit to the Alberger Pump & Condenser Co., 140 Cedar St., New York, $2,496. Noted Feb. 13.

Ia., Maquoketa—The Eastern Iowa Electric Co. awarded the contract for the construction of a hydro electric plant to Price Brothers Co., 45 Davies Bldg., Dayton, Ohio. $250,000.

Md., Baltimore—The Mayor and City Council awarded the contract for the construction of a 3 story, 260 x 295 ft. high school, including heating and ventilating systems, on Calhoun, Carey and Baker Sts., to J. H. Miller, Inc., Eutaw & Franklin Sts., Baltimore. Estimated cost $1,149,000. Noted Mar. 13.

Mass., Lowell—The Lowell Electric Light Corp., 29 Market St., awarded the contract for the design and construction of an extension to boiler room of power house to Stone & Webster, 147 Milk St., Boston. Plans include a 63 ft. extension to building, erection of a steel stack, installation of two 755 hp. boilers, with underfeed stokers, superheaters, ash hoppers and accessories, a 120,000 c.f.m. forced draft fan, and an additional feed pump, feed water heater and necessary ducts and piping. Coal conveying equipment will include a track hopper, bunker and coal crusher, with belt conveyors and bunkers in the boiler room, also an extension of the present coal storage pit and trestles. Estimated cost $373,000.

Neb., Omaha—C. and R. C. Cook, c/o George & Co., 902 City Natl. Bank, awarded the contract for the construction of a 4 story, 135 x 260 ft. store and office building on Howard St. between 16th and 17th Sts. to the J. Black Masonry & Contg. Co., 515 Federal Reserve Bank Bldg., Omaha. Estimated cost $1,000,000. Equipment detail not reported. Noted Apr. 3.

N. J., Glen Rock (Ridgewood P. O.)—The Borough of Glen Rock awarded contracts for the sewerage system, as follows: three sections to E. B. Edgar, Scotia, N. Y., one section to Alberto & Co., 208 Hamburgh Ave., Paterson. Construction of sewage disposal works and pumping station to M. Averill, 196 Woodside Ave., Newark. Estimated total cost $290,000. Noted Mar. 6.

N. Y., New York—The Paterno Constr. Co., 117 West 54th St., will build by day labor a 6 story, 110 x 500 ft. apartment building at 128 Pinehurst Ave. Estimated cost $750,000. Equipment detail not reported.

N. C., Charlotte — The Textile Office Bldg., c/o W. L. Stoddard, Engr. and Archt., 9 East 40th St., New York, awarded the contract for the construction of a 15 story, 60 x 180 ft. office building, here, to the Hunkin-Conkey Constr. Co., Century Bldg., Cleveland, Ohio. Estimated cost $1,000,000. Equipment detail not reported. Noted Apr. 3.

Pa., Phila. — The Girard Craftsman's Club, 2102 Chestnut St., arwarded the contract for the construction of a 7 story, 60 x 161 ft. club and store building at 2025 Chestnut St., to J. P. Hallahan, 2315 Walnut St., $800,000. Steam heating system will be installed.

Pa., Williamsport — The Keystone Glue Co., West Williamsport, awarded the contratc for the construction of a 45 x 70 ft. power plant on Newberry St., to The Foundation Co., 120 Liberty St., New York, water tube boilers to The E. Keeler Co., 238 West St., Williamsport. Total estimated cost $200,000.

R. I., Pawtucket—The Blackstone Valley Gas & Electric Co., 231 Main St., awarded the contract for the construction of a 66,000 volt transmission line from here to Woonsocket, two outdoor terminal substations, including transformers, switches and other equipment; also 13,000 volt underground line between Stations 1 and 2, here, and a 13,000 volt switch house at Woonsocket, to Stone & Webster, Inc., 147 Milk St., Boston. Estimated cost $1,400,000.

Wash., Kelso—The Long Bell Lumber Co. awarded the contract for the construction of a power plant, with ultimate development of 20,000 hp. at Longview, to C. Moore & Co., Sheldon Bldg., San Francisco, Cal. Estimated cost $2,000,000. Noted Sept. 26.

Wis., Green Bay—The Wisconsin Hotel Realty Co., 86 Michigan St., Milwaukee, awarded the contract for the construction of an 8 story, 130 x 160 ft. hotel on Pine St., here, to W. W. Oeflein, Inc., 86 Michigan St., Milwaukee. Estimated cost $900,000. Equipment detail not reported. Noted Mar. 13.

Wis., Tomahawk—The Tomahawk Craft Paper Co., c/o Wausau Sulphate Fibre Co., Wausau, will build a sulphate paper mill and hydro electric development. Work involves: 2 story main mill, 1 story, 34 x 110 ft. power house, also dam, 800 ft. long, 19 ft. head. Work will be done by day labor. Estimated cost $1,250,000. L. A. DeGuere, Wisconsin Rapids, Engr. Noted March 27.